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4

PRACTICAL
BUILDING CONSTRUCTION

PRACTICAL
BUILDING CONSTRUCTION

A HANDBOOK FOR STUDENTS PREPARING FOR T
EXAMINATIONS OF THE SCIENCE AND ART
DEPARTMENT, THE ROYAL INSTITUTE
OF BRITISH ARCHITECTS, THE
SURVEYORS' INSTITUTION,
ETC.

Designed also as a Book of Reference for Persons Engaged in Buil

BY

JOHN PARNELL ALLEN
SURVEYOR

LECTURER ON BUILDING CONSTRUCTION AT THE DURHAM COLLEGE OF SCIENCE,
NEWCASTLE-ON-TYNE

Containing over One Thousand Illustrations

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PREFACE.

IN this work, which is intended primarily for students in every trade concerned in Building Construction, —and which has been arranged on the basis of Notes prepared for a Course of Lectures on the subject,—the Author has endeavoured to deal, in a concise and practical manner, with all the details of the construction of a building. He has aimed also at giving such a description of the nature and characteristics of the various Building Materials in general use, as should be sufficient (with other subjects dealt with in the volume) for the purposes of the examinations in Building Construction prescribed by the Science and Art Department, the Royal Institute of British Architects, and the Surveyors' Institution, respectively.

Students who may be preparing for the Elementary and Advanced Examinations of the Science and Art Department (see Appendix, pp. 421 to 424) will be able, by following the abstract of the requirements of their several stages, to omit, in their reading, those portions of the work with which their particular class is not concerned; while Honours students, and those preparing for the Examinations of the Royal Institute or the

Surveyors' Institution, will find that the work covers the ground sketched by the Syllabus of each of those bodies.

While the courses prescribed by the several authorities referred to above are those which the Author has had specially in mind, it need hardly be pointed out that the materials here provided will be available for preparation for other examinations covering similar ground, as well as for students not seeking certificates; the Author's aim having been to provide what he believes is not to be found elsewhere in a form at once so complete and so compact—namely, a HANDBOOK of PRACTICAL BUILDING CONSTRUCTION, which should be found useful by all who seek proficiency in the rudiments of the Building Arts.

It is believed, also, that the work will be found of material service as a Book of Reference by both Operative and Master Builders, as well as by Houseowners and Estate Agents, Surveyors and Architects, and others whose interests are to be promoted by acquaintance with its subject.

It should be mentioned that the numerous diagrams and other illustrations, about one thousand in number, have been specially drawn and engraved for this work.

The Author takes this opportunity of tendering his thanks to those personal friends and other gentlemen—specialists in their several departments—who have so kindly assisted him with their suggestions in relation to one or other portions of this work.

NEWCASTLE-ON-TYNE,
September 1893.

PUBLISHERS' NOTE TO SECOND EDITION.

IN issuing the present edition, the opportunity has been taken by the Author of carefully revising the work throughout, and of inserting a few additional illustrations, with the necessary explanatory text. A few of the original illustrations have also been re-drawn, with a view to greater effectiveness. Subject to these several improvements, the work is again issued, without abridgment, substantially in the form in which it has already attained to such extended popularity as the "best and most complete text-book on Building Construction."

September 1897.

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PRACTICAL
BUILDING CONSTRUCTION.

CHAPTER I.

BRICKS AND THEIR COMPOSITION.

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Bricks as Building Material.—Bricks, the chief material of the bricklayer, are hard rectangular blocks, of an originally clayey substance, which has been tempered and moulded into the shapes required, and then burnt in a clamp or kiln until it is quite hard.

Bricks are an ancient building material, having been made and used by the Romans for arches, facings, pavings, etc. Though they were, at that period, of larger and smaller sizes than those used generally in the present day, they were always made with half-bricks or double bricks—double their width in length—to allow of bond, as will hereinafter be explained. They thus varied in length from 7½ to 22 inches, and were generally very thin (about 1½ inch), the smaller sizes being used for facing rubble walls, and the larger sizes for bonding every fourth course or thereabouts. The latter were also used for arches.

In more modern times bricks have been used for walling, facing, arches, and paving; and generally their dimensions are now about 9 inches long by 4½ inches (or half their length) in breadth, so that two laid crosswise will cover two laid lengthwise. They are made from 2½ to 3½ inches in height, according to local custom or the requirements of construction.

They are of numerous different qualities, kinds, and colours, each from its peculiar nature adapted to a particular purpose or use. A concise classification of the various kinds, their peculiarities, qualities, and uses, will be given hereinafter.

It is to be noted that the quality of a brick depends on the clay from which it is made, and on the different manipulation which the clay will allow of in its manufacture.

Brick-earth and its Constituents.—A good brick-earth or clay, such as is used for common red bricks, is generally composed of silica and alumina, accompanied by a slight percentage of lime or other flux (to fuse the two into a hard mass), and a still smaller percentage of oxide of iron, manganese, magnesia, or an alkali to give it its colour. The properties of the different constituents of clay are as follows :—

Silica, the greatest in bulk, is practically sand : that is, in an uncombined state, it is infusible, whether alone or with alumina, without a small quantity of flux in the form of lime or oxide of iron ; and it acts as a preventative to cracking, shrinking, or warping. Up to a certain proportion the more silica there is the better the shape and more even the texture of the resulting brick. An excess of silica (or sand) renders a brick too brittle. The silica should be in chemical combination with the alumina, as opposed to a mere mechanical admixture.

Alumina is the principal and most important constituent of a good clay, as it imparts the plastic qualities, though it shrinks, cracks, and warps very considerably under the influence of heat, which renders it very hard.

Lime may be called a flux, though its presence in the bulk has a double effect : it both diminishes the contraction in the process of drying the raw material, and it blends the silica and alumina together in the burning. This carbonate of lime must be present in very small quantities, comminuted and equally distributed throughout the mass ; for if it exists in lumps it will be slaked by moisture, and cause the disintegration of the brick, whether laid or not in the finished work.

Iron is also a flux, when in the form of an oxide, and in the presence of nearly equal quantities of silica and alumina. It is the colouring matter of most kinds of bricks, the intensity of the colour (from a light yellow to a dark red) being in proportion to the quantity of iron oxide present. With 8 or 10 per cent. of oxide of iron, the colour is a dark blue or purple, and the addition of a small proportion of *manganese* gives almost a black colour to the brick ; and with lime the two impart a cream colour, the one darkening and the other lightening the shade. *Magnesia* and *iron oxide* make a yellow brick. The presence of *alkalies* is generally a source of trouble, as they act too strongly as a flux when in any quantity, though that may be only a small percentage. They melt the clay, as it were, and render the resulting brick unsymmetrical, while giving it a greenish-blue tint.

A *good brick-earth* contains silica and alumina in due proportions, together with such a percentage of a flux (in whatever form) as will fuse the silica and alumina without running the bricks together and rendering them vitrified.

Varieties of Brick-earth.—There are three different kinds of brick-earth, as follows:—

1. *Pure clay*, also called *Plastic* or *Strong* clay, which contains silica and alumina, with such a small proportion of lime, iron oxide, or other flux that the brickmaker calls it "foul clay," as it is of very little use by itself, a soft, uncombined brick being the result of what little burning the clay will stand. The addition of more lime or other flux improves the clay greatly for brick-making purposes.

2. *Sandy*, *Mild*, or *Loamy* clays are so loose that they are useless for the manufacture of bricks unless a flux is added in sufficient quantity to make the fusion perfect.

3. *Marls* or *Limy* clays are the best of all, as they contain the necessary constituents in the first instance, without further addition, except to regulate the burning.

An artificial brick-making clay of this quality, called *malm*, can be obtained by washing the clay and mixing it with the necessary lime in a mill.

Having dealt with the qualities and peculiarities of the different clays and their constituents, a short *résumé* of the process used in the preparation of the clay and manufacture of the bricks may with advantage be given before proceeding to a detailed classification of the different kinds of bricks and their characteristics.

Manufacture of Bricks.—After the removal of the turf and surface-soil, which is called *encallowing*, the clay is dug out, in the autumn, and placed in heaps or places called *kerfs*, and there the different kinds are mixed together and other ingredients added, as the nature of the clay requires, for the production of a first-class article. Of course, all stones and other unsuitable substances are picked out, and sometimes, when the clay is hard or uneven, it is ground in a mill to a finer admixture.

This done, the clay remains in these heaps or kerfs during the winter; and, about the end of March, the winter's seasoning having reduced its liability to warp, the clay is turned over, trodden under foot, or ground in a mill, which tempers the clay and renders it ready for conversion into bricks.

Malm, the washed and artificial brick-making earth, is likewise made in the autumn by mixing the newly dug clay with a proportion of chalk, to make up the deficiency in the natural constituents. This is done in a mill, and as soon as the mixture becomes of a creamy nature, it is run through large sieves into what are called *backs*, large tanks in which the substance becomes hardened, after which a layer of fine screened ashes is sandwiched between two layers of malm, and in this condition the mass remains during the winter to mellow.

The clay or malm being thoroughly ripe, it is ready to be made into bricks, which can be done by machinery or by hand, the latter making the better bricks.

Machine-made Bricks.—Machine-made bricks are of two kinds, dry or plastic; in the latter case the clay, when still in a soft, sticky condition, is forced by pressure through a rectangular channel of indefinite length but the width of a brick lengthwise and the height of a brick on edge (that is, about 10 in. × 5 in.) on to a smooth greased iron platform. When sufficient has descended on to the platform, the supply through the channel is cut off, and what remains, being 10 in. × 5 in. and of indefinite length, is cut by knives or wires, in a frame worked by machinery, into the height of the brick required—whether it be 2½ in. or 3 in.

This, in the course of a few seconds, cuts a definite number of bricks out of the clay, and these are carried away to a shed or out into the sun to dry gradually.

Machine-made bricks can also be formed from clay which has been dried and ground to a powder, which is put into a mould (as explained hereinafter in treating of hand-made bricks) and subjected to great pressure, so that a consolidated mass is formed of very even surfaces. The resulting brick, being already dry, is ready to be burnt in the kiln.

Hand-made Bricks.—Hand-made bricks are of two kinds, *slop* or *sand*-moulded; the difference being that, for the former, the mould (which is made a little larger than the ultimate size of the brick required, so as to allow for shrinkage as the clay or malm dries) is dipped into water, to prevent the clay from adhering to its sides; whereas for the latter the same end is attained by sprinkling the inside of the mould with sand, fine ashes, or a specially ground powder.

Sand-moulded bricks are considered to be cleaner, more sharp, regular, and perfect in shape than *slop*-moulded bricks. In both cases alike, the clay or malm is pressed by hand into the mould on a flat and smooth table, and the superfluous clay is cut off by a straight edge.

The rectangular block of clay is then turned out of the mould and taken to the shed to dry, exactly as with the machine-made bricks.

In some cases a *frog* or indent is formed on the bed of a brick, either hand-made or made by machine; or the brick may be made by hand and afterwards machine-pressed to give it a closer body and finer finish.

This *frog* or *kick*, as it is called, is made by a projection on the stock board, over which the mould is placed and fitted to form a bottom before the clay is pressed home within the mould to form the brick; or in the case of machine-pressed bricks, projections are left on the top and bottom plates of the pressing box.

Drying.—The soft, half-dry bricks are then dried gradually, in the sun or under sheds, being *scintled*, that is, stacked diagonally, so that the air can have free access all round them. When they are dried out of doors, they are placed on *hacks*; these are long narrow banks, raised above the ground which is covered with dry material, such as ashes or brick rubbish, to reduce the moisture to a minimum and to facilitate the drying process.

Burning.—When the raw bricks are sufficiently dry they are wheeled into the kilns or clamps and stacked in layers, sometimes diagonally, to allow of a perfect circulation of the heat from a bottom of burnt bricks, covered with six inches of breeze, channels, filled with faggots, being left across the bottom to draw the heat. This done, and the clamps covered up or the ends of kilns blocked, the fire is lighted and kept burning for a period of from two to six weeks, after which they are allowed to cool, and the brick is then ready and fit for the builder.

Clamp-made bricks should always have a certain amount of ashes or breeze incorporated in them in the mixing, so that they may take the fire better and burn more readily.

Clamps are chiefly used in country brickyards, and for temporary purposes; they consist of walls, built of dried raw bricks, smeared with clay to hold the heat, and encircling a honeycomb of flues, on which the bricks to be burnt are stacked, on layers of breeze, laid over the flues, in such a way as to leave each brick as far as possible exposed on all sides to the heat during the process of burning; and they are then covered over by a few courses of burnt bricks, after which the fires are lighted, when the whole mass, connected by the flues, commences to burn gradually.

Kilns.—Kilns are more permanent structures, and may be either circular or rectangular in plan, the former being the better of the two; but a detailed description of them is beyond the province of these notes. Glazed bricks are burnt in domed kilns.

Defects.—As soon as the bricks are cool they are fit for use, though they require some selection; those near the flues being over-burnt and run together, called *burrs*; and those near the outside being soft and more or less imperfectly burnt, called *place bricks*, *grizzles*, or *samels*.

Chuffs are bricks on which rain has fallen while they are hot, making them full of cracks, and otherwise wholly defective.

Sound Bricks.—A sound, good brick should be hard, well-burnt, square, and regular in shape, with clean sharp arrises. It should give a clear ring when struck; be free from lumps of lime and other impurities, and as non-absorbent as possible.

Varieties of Bricks.—The chief kinds of bricks at present in the market, and their characteristics, are as follows:—

Gaults are bricks made from a natural clay with sufficient lime in the form of chalk to act as a flux. They are made in the southern and eastern counties, and are very hard, heavy, and durable, of the first quality, suitable for best facings, and usually of a white colour, though the inferior bricks have a slight pinky tinge. The *Cambridge* common white bricks have a proportion of pinky ones, the mixture being classified as *Mingles*.

Malms, as the name implies, are made from a marl or chalky mixture, and principally used for facings and other best work. *Suffolk bricks* are of a similar quality, and mostly of a light colour.

Common firebricks are made from a refractory clay containing almost pure alumina and silica in the proportion of one part of the former to three parts of the latter; they are generally of a whitish yellow or light brown colour, and rather porous. They should be uniform in texture, and of course free from lime and iron. They are made chiefly in Shropshire, Staffordshire, and near Leeds, Newcastle, and Stourbridge. They are used for lining blast furnaces, setting grates and boilers, and casing fire-resisting flues and furnaces, and in fact in any position where brickwork is exposed to the action of fire.

Dinas firebricks are made in Glamorganshire from sand, *i.e.*, pure silica, which is mixed with 1 per cent. of lime and a little water, and pressed together by machinery before burning. They are the best firebricks in existence, of a porous nature, and they will expand and withstand an enormous heat.

Ganister bricks are made from a hard fireclay marl found in the coal measures, which is ground and pugged and moulded in the ordinary way. They are closer in grain, and superior to firebricks for furnaces, etc.

Guismuyda firebricks are similar to the Dinas bricks.

Lee Moor firebricks are made near Plymouth, from the refuse of china and clay, and are very hard, compact, and of a dull red colour.

Thompson's are light, strong, fireproof bricks, lately introduced from Cheshire; they are of a common red colour, and extraordinarily light in weight.

Glazed bricks are made extensively in the south-west of Scotland, in Wales, Warwickshire, Yorkshire, Northumberland, and Durham, from the best qualities of fire-clay, which is generally ground much finer than for firebricks. Glazed bricks are made by hand and machinery (the latter chiefly), and all, when sufficiently dry, are pressed and as fine a skin put on them as possible; after which the glaze, of whatever tint required, is put on by either of two methods, called respectively the *dry* and *wet dip*. Of these two methods the former is the better, because the previous drying (as hereinafter explained) prevents any further contraction.

The *dry dip* consists of dipping the bricks in the glaze after they have been once burnt in the kiln; whereas, in the "wet dip" process, the glaze is applied to the wet, undried, or unburnt bricks. After they have been dipped each process is completed by burning the bricks at a very high temperature. Glazed bricks are generally one-eighth of an inch higher than the ordinary kinds, so as to reduce the mortar joint; and they may be either glazed at one end or one side only, or at both ends, both sides, or on end and side as required.

Fareham and Woodville red bricks are of a close, sandy nature; or they can be made smooth, coming from a moderately plastic clay. Their deep red, even colour, and good surface, render them most suitable for facings.

Staffordshire or Nuneaton blue and black bricks are very hard, well-burnt and close, non-absorbent, and will resist enormous weights and pressure. They are used for damp courses, pavings, weatherings, piers, dressings, and positions requiring great compressive strength, and for damp situations. They are made from a clay containing about 10 per cent. of oxide of iron, which gives them their colour. The clay is also made into copings, channels, and many other specialities.

Black bricks, made in Berkshire, have no uniformity in colour, but are hard, close, and sandy in texture, and make a good mottled front, their ends being alternately black, blue, and a glazed yellow or white: so much so that they give the appearance of being daubed irregularly with soot before being burnt.

Rubber bricks are of a soft, sandy nature, of fine, rich, red colour, and capable of being cut, carved, or rubbed into any shape or form. They are made near Birmingham and Bracknell, and should be compact, of uniform colour, texture, and hardness, so that they cannot be scored with a knife, even in the centre; while they should rub well. They are generally made slightly larger than ordinary bricks, to allow for the rubbing down.

Dutch or adamantine clinkers are small, cream-coloured, and very hard bricks, vitrified throughout, and used chiefly for paving; and, if anything, the Adamantine is the better brick of the two for the purposes required. They are grooved or chamfered, to give a firmer foothold for horses, etc., in pavings.

Candy's bricks are of a similar character, though perhaps harder and yet more brittle, and they are supposed to "wear rougher." They are of a lighter colour, of a more watery appearance, and suitable for the same purposes as the clinkers.

Concrete and breeze bricks are made of cement and gravel or breeze, and used for fixing purposes. They are supposed to be fireproof, and yet suitable and easy for use with woodwork to be attached thereto.

Dust bricks are blue bricks, which have been made in moulds sprinkled with dust instead of sand.

Pressed bricks are those made by machinery under pressure, and *Dressed bricks* have had their sides and beds beaten with a "dresser," which gives them a better arris and more even face.

Of course, it will be understood that most of the above kinds of bricks can be moulded (before being burnt) into any shape, form, or size, to suit requirements.

Purpose-made Bricks are of innumerable kinds, and made in various clays. The chief kinds are enumerated below, though it must be understood that this list is not, and cannot be made, exhaustive; special circumstances requiring special bricks, which should be ordered early, before the operations of building are commenced, so that no delay may be caused while they are being made, as their manufacture occupies a considerable time in some cases.

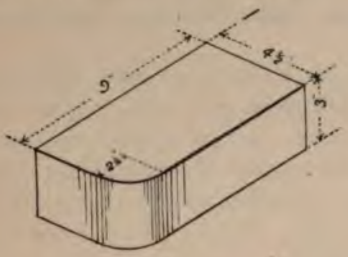


Fig. 1

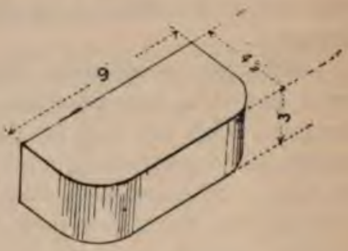


Fig. 2.

Bullnoses are bricks with rounded angles. On the accompanying plate (showing special-purpose-made bricks) fig. 1 represents a bullnosed angle to a 2¼-inch radius; fig. 2 a double bullnosed angle to a 2¼-inch radius; fig. 3 a bullnosed angle to a 4½-inch radius; fig. 4 a double bullnosed angle to a 4½-inch radius.

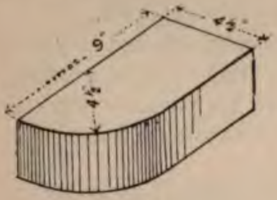


Fig. 3.

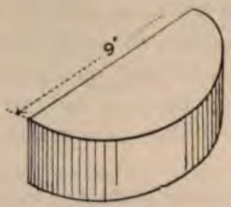


Fig. 4

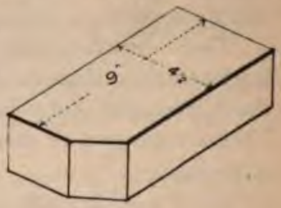


Fig. 5.

Cants are jamb-bricks with an angle cut, as shown in fig. 5; fig. 6 being a double cant.

Birdsmouths are for internal angles other than right angles; fig. 7 representing a stretcher and fig. 8 a header. The converse, as shown in fig. 9, is called a *squint*, and is used for external angles.

Jamb-bricks of another kind are represented by figs. 10 and 11; while fig. 12 illustrates a *string* brick, and figs. 13 and 14 stretcher and header *plinths*.

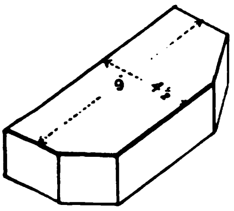


Fig. 6.

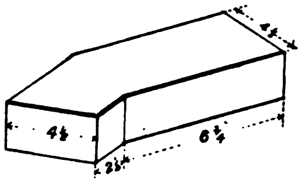


Fig. 7

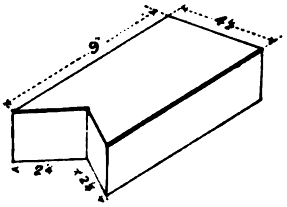


Fig 8.

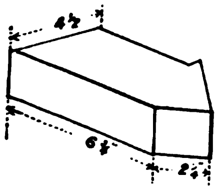


Fig. 9

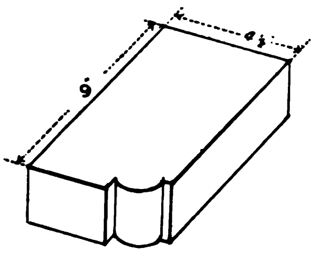


Fig. 10.

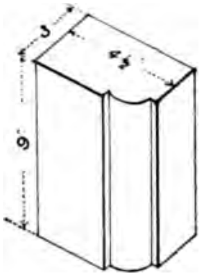
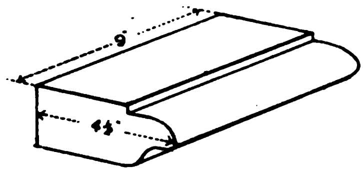


Fig. 11.



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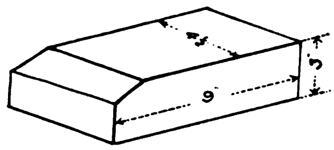


Fig. 13.

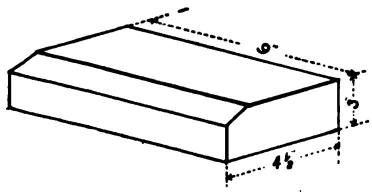


Fig. 14

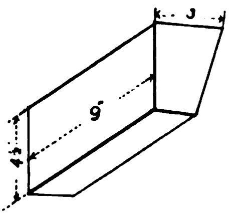


Fig. 15.

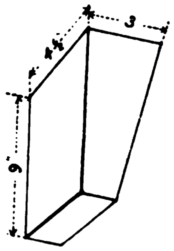


Fig. 16

Of the one-centred *arch* brick, figs. 15 and 16 show respectively a header and a stretcher, and fig. 17 a *compass* brick, fig. 18 representing a *circular* brick.

Camber arch-bricks are shown by fig. 19, and *elliptical* arch-bricks by fig. 20.

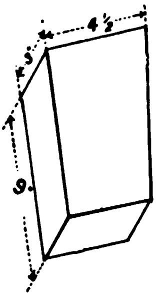


Fig.17

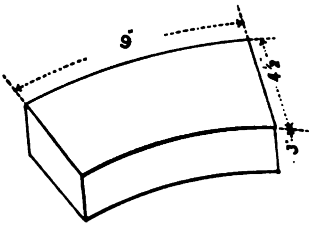


Fig.18.

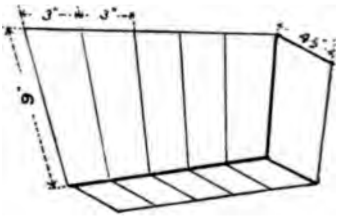


Fig.19.

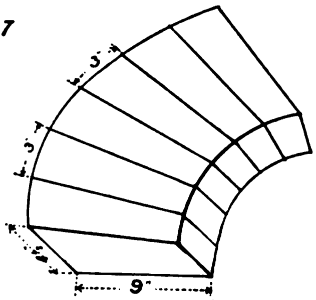


Fig.20.

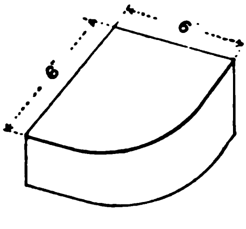


Fig.21.

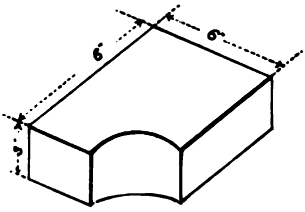


Fig.22.

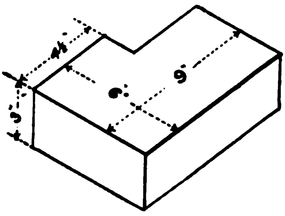


Fig.23.

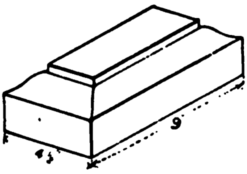


Fig.24

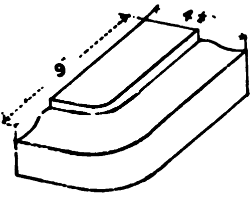


Fig.25.

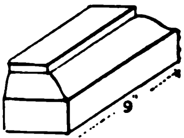


Fig.26.

External rounded angles are represented by fig. 21, and internal ditto by fig. 22; while square angles, both internal and external, are depicted by fig. 23.

Of *moulded* bricks, quoins are illustrated by fig. 24; moulded bullnoses by fig. 25; moulded squints by fig. 26; moulded cants by fig. 27; external angles by fig. 28, and internal angles by fig. 29.

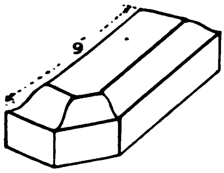


Fig. 27.

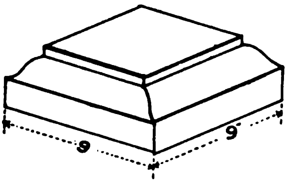


Fig. 28

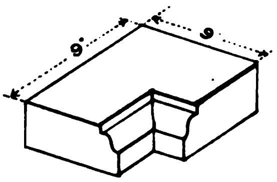


Fig. 29.

Soaps are bricks 9 inches long, 2¼ inches only in breadth, and 3 inches high; while *splits* are 9 inches long, 4½ inches broad, but only about 1½-inch high (or thick).

Stocks are the sound marketable clamp burnt London bricks when the "place bricks" have been removed and the "picked" stocks selected for superior purposes—the "stock" is the medium quality—and they are mostly burnt in clamps, having a quantity of ash refuse and breeze incorporated in them, so that very little fuel is required to burn them.

Brindled bricks are inferior common blue bricks, of a browny blue colour, very hard and durable, and suitable for engineering purposes. It should be noted that good blue bricks are made out of a hard blue or purple marl, which is ground to a powder and pugged into a plastic state ready for moulding. The best and soundest bricks are excellent for all damp situations, some being specially annealed for use in storage tanks for chemical gases, etc., and all true blue bricks should be close, hard, and absolutely non-absorbent, though not necessarily blue all the way through. Sometimes *dust* bricks are made by the dry process similar to tiles.

CHAPTER II.

BRICK BOND AND ITS APPLICATIONS.

Brickwork defined—Bond in Brickwork—Structures of Brickwork—Different Kinds of Bond—Application of the Various Bonds.

BRICKWORK strictly speaking is understood by the trade to mean work executed with standard-sized bricks, *i.e.*, 9 inches long, 4½ inches wide, and from 2½ to 3½ inches high, and any larger-sized materials used are considered out of the province of the bricklayer.

Bond in Brickwork.—The principal point which the bricklayer must always have in view in his work, beyond good workmanship, with the good materials given to him, is to have one pervading bond throughout each separate piece of work, so that the many bricks used will form one continuous unbroken mass from every point of view. By this word *bond* —which is the very essence of sound work—is meant the arrangement of the bricks in such positions beside and above each other, that no single vertical joint between any two bricks is immediately in line and above that between two others; that is to say, the bricks must always break joint on the solid surface of a brick beneath.

A straight vertical joint between two bricks exactly over a similar joint of the course below is exceedingly bad construction, and an unsound, weak piece of work, which should never be overlooked. Moreover, in good bond the bricks should *break joint* vertically both in the length and thickness of the wall, so as to bind the several bricks forming the mass into one solid piece of work, and fairly to distribute the superincumbent weight.

Fig. 30 illustrates this principle of breaking joint, and also its object and effect in distributing the load, as the dotted lines show how it is carried from one brick on to the centres of the bricks below.

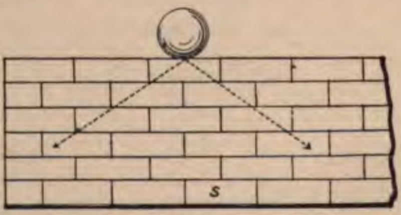


Fig. 30.

Fig. 31 shows a piece of walling with no *bond*, or *breaking joint*, and fig. 32 the effect a heavy load would have on an unsound foundation; the bricks immediately underneath the weight would sink down, and leave those adjacent to them, on each side, in their original position. The same applies to the thickness of the wall as well as to its length, as shown in figs. 33, 34, and 35, on the same principle.

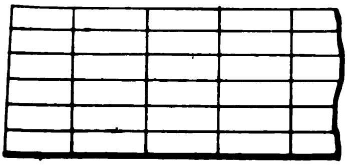


Fig. 31.

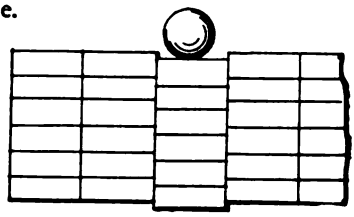


Fig. 32.

Having shown the necessity for such a principle, to break joints and effect a bond both lengthwise and crosswise, it will be convenient, before proceeding, to explain the modes of carrying out that principle: first, to note that all longitudinal joints, or the beds of the bricks, must be perfectly horizontal, so that the vertical joints can be made perfectly perpendicular without unnecessary trouble, inasmuch as all bricks are, or should be, made rectangular in form on all sides.

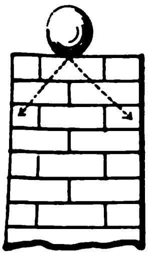


Fig. 33.

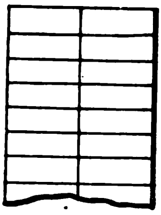


Fig. 34.

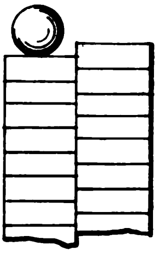


Fig. 35

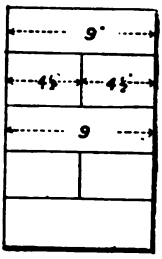


Fig. 36.

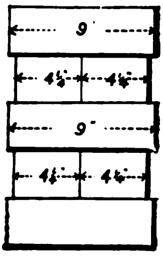


Fig. 37.

The standard size of a brick being 9 inches long, 4½ inches wide, and 3 inches deep, the brick is twice as long as it is broad. The necessity of this proportion is illustrated by the vertical transverse section of a 9-inch wall, properly bonded, as shown in fig. 36; from which it will be obvious that the front and back surfaces of this wall would be uneven—*i.e.*, in and out each alternate course—if the two small sections were not the exact equivalent, in form and dimensions, of the one long one. Fig. 37 shows the result of such a defect. Of course, a little must be allowed for the mortar joint; and for this purpose the width of a brick is always barely 4½ inches—say, generally about 4⅜ inches—thus leaving a quarter of an inch joint in 9 inches, which should scarcely ever be exceeded.

From these illustrations it will be obvious that, with the use of bricks of one standard and regular size, the bond must be obtained by laying the bricks in different directions—one course transversely with two others longitudinally side by side, and so on.

A brick which measures, when laid, 9 inches long and 3 inches high on the face or back of a wall, is called a *stretcher*; and one which shows $4\frac{1}{2}$ inches long and 3 inches high is called a *header*; and consequently a whole horizontal course of stretchers only is called a *stretching course*, and one of headers alone a *heading course*.

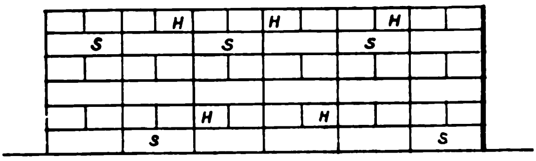


Fig. 38.

The thickness of a brick wall is either defined by inches or by the number of *header* bricks; a 9-inch wall being described as a 1-brick wall, a 14-inch as a $1\frac{1}{2}$-brick, an 18-inch as a 2-brick wall, etc.

Now, we know that when stretchers are laid in every course, we have a bond in which the bricks of every course break joint over the centre of the bricks below, as shown on fig. 30. But if you use one course of headers and one of stretchers on the face of the work, the bricks only break joint properly at every other joint—*i.e.*, one joint in two, as shown in fig. 38; whereas, by alternating the headers and stretchers in every course, though the same defect has to be contended with, it is in lesser degree, viz., only in the proportion of one unbroken joint in three, as shown in fig. 39, instead of one in two, as fig. 38. To remedy this, recourse has to be had to the use of $\frac{1}{4}$-bricks, called *closers*, which are placed at the angles or *plumbings*, the only places where they are legitimate and allowed in good brickwork. This gives a *three-quarter bond*, which means that the joint is broken either in the centre of a header or on the first or third quarter of the stretcher, as shown on fig. 40.

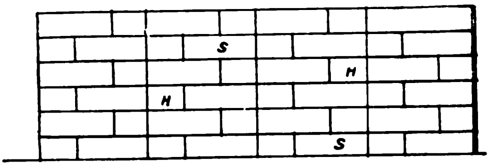


Fig. 39.

While dealing with closers it will be well to point out that there are three kinds of closers, as follows:—

Queen closers, or *through* quarters, as fig. 41, an *ordinary closer* being shown on fig. 42.

King closers are cut to shape, as fig. 43, showing 2¼-inch face, and, with 4½-inch at back, 9 inches inwards.

Bats may be either ¼, ½, or ¾ bats, according to the proportion they bear to the size of a whole brick.

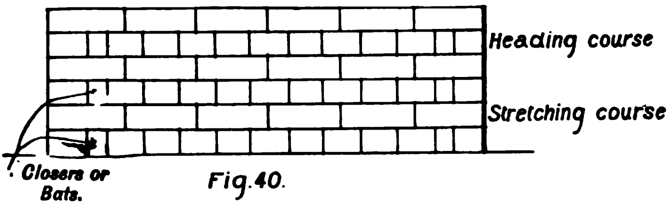


Fig. 40.

Having got all our materials, and their several sizes, positions, and duties assigned, it will be as well to emphasise a few points and rules which must be adhered to in all kinds of bond before giving a description of the varieties of bond.

Structure of Brickwork.—The cardinal points of brickwork, to be attended to under all circumstances, are:—

1. To place a *closer next to the first header in each alternate course* where there is a *plumbing—i.e.*, after the header, at each and every angle where a bricklayer has to use his plumb-rule to mark the upright line correctly perpendicular, whether it be at an angle of the building, window or door jamb, projection or recess. There can be no exception. The student must also note that the brickwork in each course is started at both ends, that is, at each plumbing, and worked towards the centre between the two plumbings. Therefore any odd-sized bricks, to make up given lengths, must come in the middle, and there only; and every closer must be within 7 inches of every angle or plumbing.

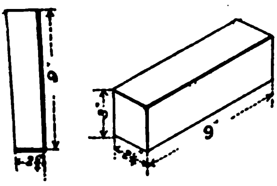


Fig. 41.

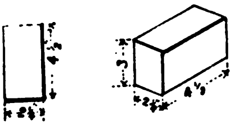


Fig. 42.

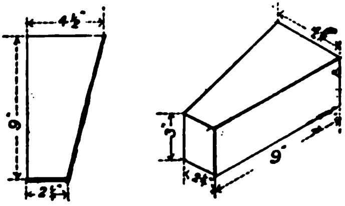


Fig. 43.

2. To bear in mind that the *closers go in pairs* in the same course—*i.e.*, one must be placed at each end, or else there would be a toothing at the other end, as shown in fig. 44; the correct and only way to make the work in order being as in fig. 45, which shows a closer at each end, and at each jamb of the window.

3. To take care that the *closer* (or ¼-brick) goes through the *whole thickness* of the wall, and in a broken line, if possible; a similar defect to

the last-mentioned being the result of inattention to this rule; *vide* the comparison of lengths of figs. 46 and 47, representing the plans of the heading course, with closer for a wall 18 inches thick.

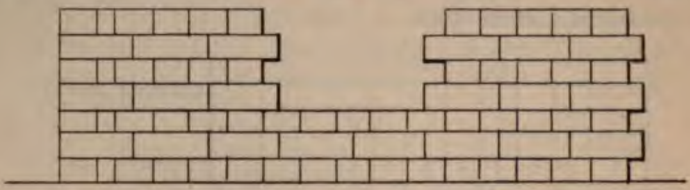


Fig. 44.

4. To *tie* internal angles, where possible, *with headers*; 2¼ inches showing in elevation, and the other 2¼ inches being within the angle of the wall.

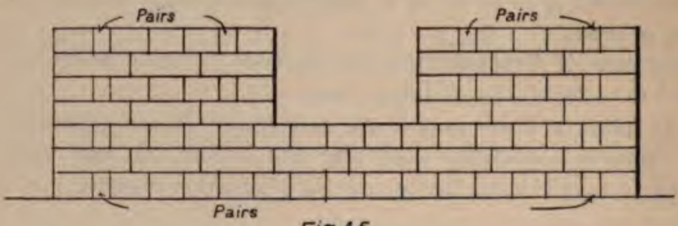


Fig. 45.

5. To start every *heading* course at *both ends*, as in fig. 48*a*, filling in according to the bond specified; and the *stretching* course must begin at *both ends*, as shown in fig. 48*b*, the filling in being according to bond specified.

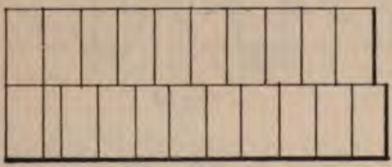


Fig 46.

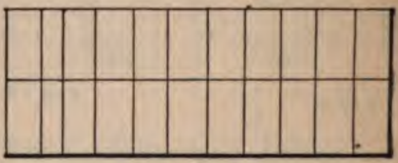


Fig. 47.

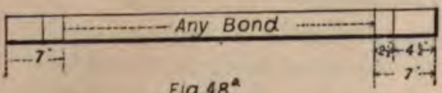


Fig 48^{a}

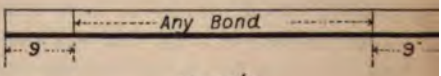


Fig 48^{b}

Different Kinds of Bond.—There are a considerable number of different bonds, including the following:—

Heading bond, which consists entirely of headers, is very seldom used because of the difficulty there is in making a finish and bond as well, it being necessary to use a stretcher at the commencement of each alternate course, as shown in fig. 48. It can only be used for walls of the thickness of or exceeding 9 inches.

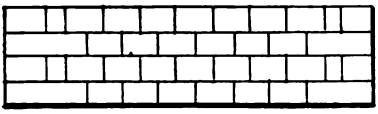


Fig. 48

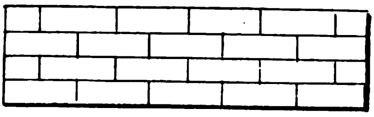


Fig. 49.

Stretching bond (fig. 49), as the name implies, consists of stretchers only, with headers at ends to bond; and is suitable for walls 4½ inches or ½-brick thick only, being practically no bond at all in thicker walls, as shown at X in fig. 50. It is also used for chimneys, which are only 4½ inches thick; and is accordingly sometimes called *chimney bond.*

English bond consists of one row or course of headers and one of stretchers alternately, as in fig. 51. This is the simplest, best, and strongest form of bond, employing a good combination of cross and longitudinal ties.

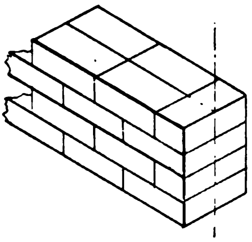


Fig. 50.

Flemish bond, as in fig. 52, is built up of alternate headers and stretchers in the same course, and may be said to look better in elevation than "English," though this is its only advantage, the latter being much stronger owing to the extra number of headers required. "Flemish" certainly makes better 9-inch walls, because the unevenness of walls showing two faces is not so apparent with courses of alternating header and stretcher, instead of alternate heading and stretching courses.

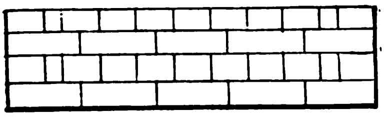


Fig. 51.

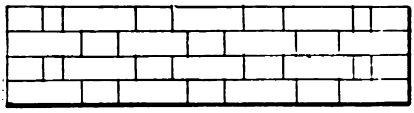


Fig. 52

There are two kinds of "Flemish bond," similar in elevation but differing on plan, called *single* and *double*; the latter showing a "Flemish" face on each side (as shown on the plans in figs. 75 and 76, 82 and 83, etc., pp. 21, 22), and the single a "Flemish" face outside, and "English" inside (as in figs. 78 and 79).

It will be noticed that *single Flemish* bond is only applicable to walls of 14 inches and over in thickness, and that it entails the use of *false* or half-headers, a 14-inch wall being formed of two skins, not bonded together in the one course, and only slightly bonded by alternate headers in the others. It is a very inferior bond, and only used to save expensive bricks in facings; as one whole brick will answer for two false or snap headers, which come inside in the Double Flemish.

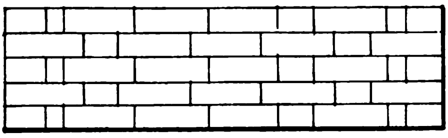


Fig. 53

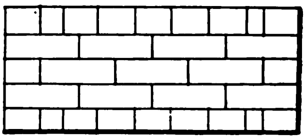


Fig. 54.

Garden-wall bond, a commonly used bond in inferior 9-inch work, may either consist of one header to three stretchers, as in fig. 53, or one course of headers to three courses of stretchers, fig. 54; the former being called *Flemish garden-wall*, and the latter *English garden-wall.*

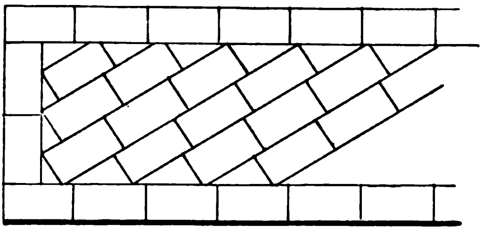


Fig. 55.

Raking bond can be of two kinds—either *diagonal*, as fig. 55, or *herring-bone*, as fig. 56. It is used for thick walls only, with an outer casing of another kind, only bonded inwardly occasionally. It is, on the whole, a useful longitudinal bond inside; though the triangular fittings next the outer skin are an objection and defect.

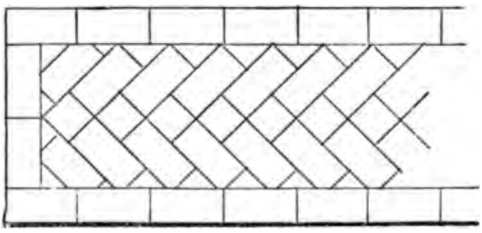


Fig. 56

Footings should always be bonded, or break-joint; and this can be effected without closers by making the offsets 2¼ inches, instead of using a closer. For this purpose English bond (if it may be called so) is the best, most suitable, and most used; as all bricks in footings should show as headers, and whatever stretchers are absolutely necessary must be used in the *middle,* because an offset taking place over a stretcher allows of only 2¼ inches bearing for the top brick, as shown by fig. 57. All offsets should be 2¼ inches, and the bottom course of footings generally double the width of the wall built thereon; the steps rising either 3 or 6 inches per offset. Figs. 58, 59, and 60 represent the footings of a 9-inch wall in plan, front and sectional elevation; figs 61 and 62 those, respectively, of a 14-inch and 18-inch wall in sectional elevation. These will require no special explanation if the student has mastered the points previously

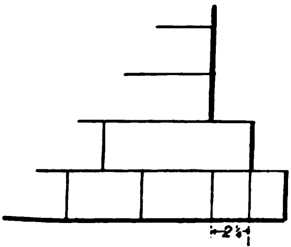


Fig 57.

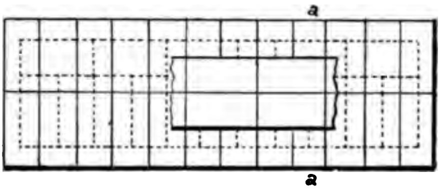


Fig.58

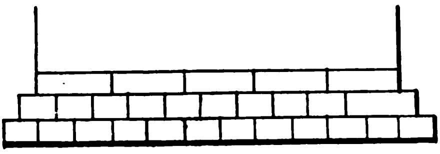
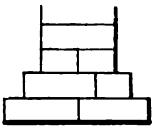


Fig.59.



End Elevation

Fig.60

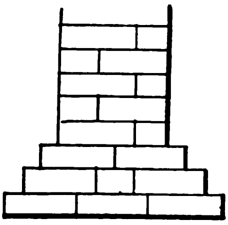


Fig.61.

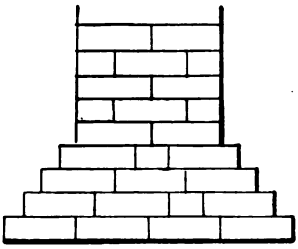


Fig 62

enumerated; it being remembered that the first course of the wall above the footings should be a stretching course—*i.e.*, start with a stretcher.

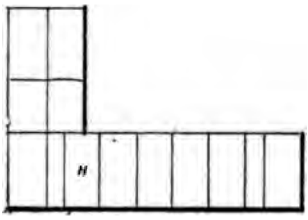


Fig. 63.

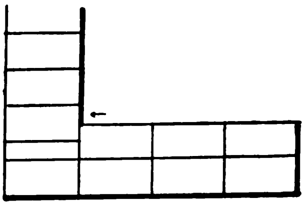


Fig. 64.

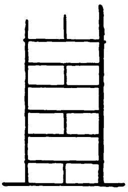


Fig. 65.

Application of the Various Bonds.—The angles of walls are given below; the attention of the student having been called to all really essential points, except that the closer course in pairs comes alternately on each side of the angle, as the brick at the angle, which is header to one face, is stretcher to the other, and *vicè versà*; and the student should note also that the internal angle is bonded in one way in one

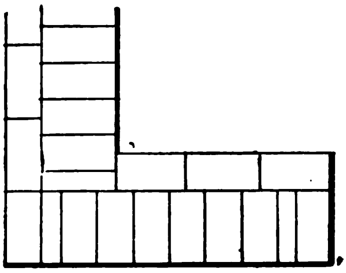


Fig. 66.

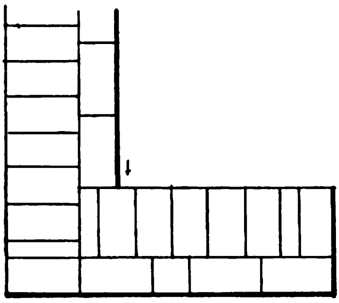


Fig. 67.

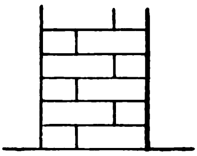


Fig. 68.

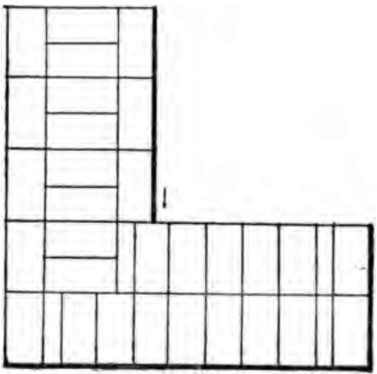


Fig 69.

course, and the other way in the next course, alternately (as shown by the arrows), and always with a header, if possible.

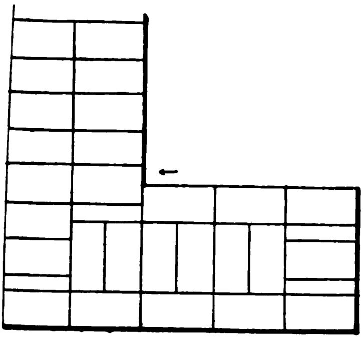


Fig. 70

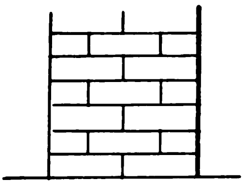


Fig. 71.

Figs. 63, 64, and 65 represent, in plan and section, two alternating courses at a corner or angle, with a blank end of 9-inch wall, *English*

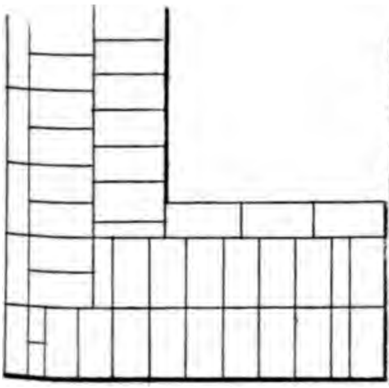


Fig. 72

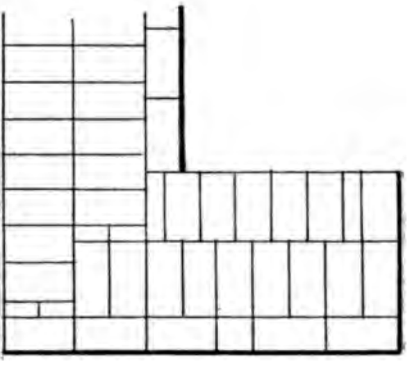


Fig. 73.

bond; and figs. 66, 67, and 68, 69, 70, and 71, and 72, 73, and 74, the same for a 14-inch, an 18-inch, and a 22-inch wall respectively.

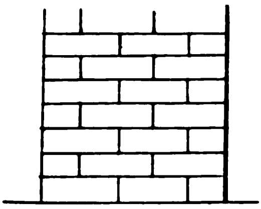


Fig. 74

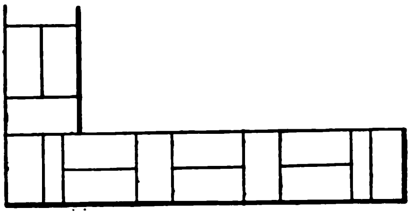


Fig. 75.

Figs. 75, 76, and 77 illustrate, similarly, a 9-inch wall in *Flemish* bond;

figs. 78, 79, 80, and 81, the same for a 14-inch wall in *single* Flemish

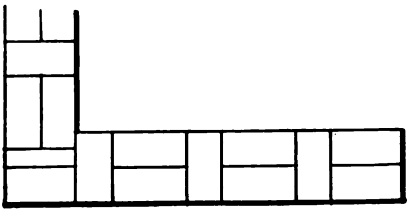


Fig.76.

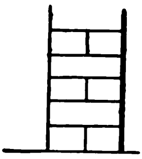


Fig.77.

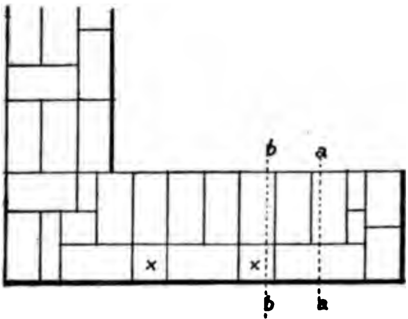


Fig.78

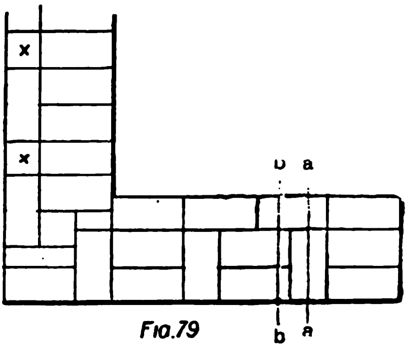
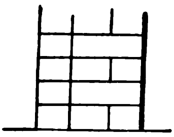
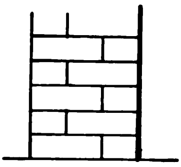


Fig.79



Section bb.
Fig.80.



Section. aa.
Fig.81.

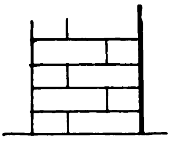


Fig 84

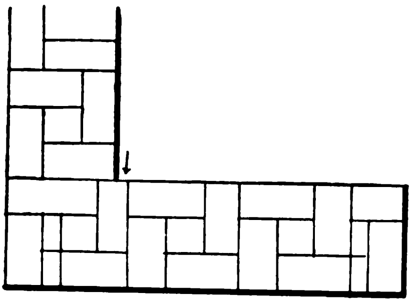


Fig 82.

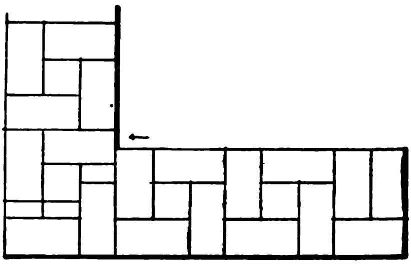


Fig.83.

bond, showing false headers, marked thus X X; *double* Flemish bond for the same being shown in figs. 82, 83, and 84; while, for an 18-inch wall, *double* Flemish bond is shown in figs. 85, 86, and 87; and *single* Flemish bond in figs. 88, 89, and 90. Finally, figs. 91, 92, and 93 show a 22-inch

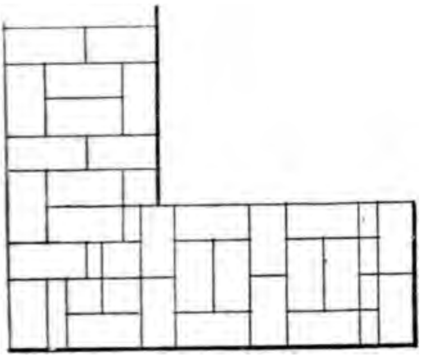


Fig 85.

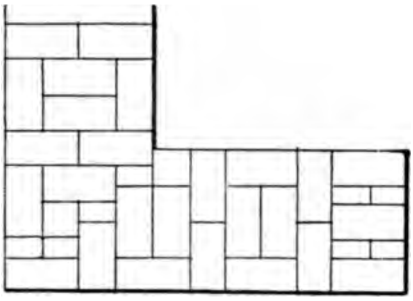


Fig. 86.

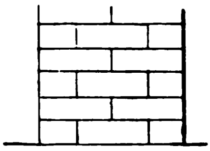


Fig. 87

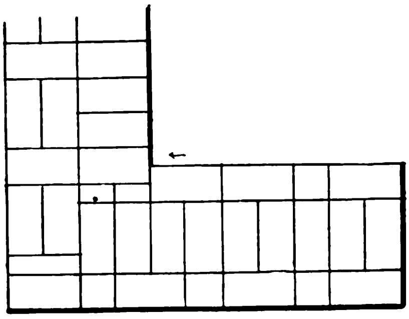


Fig. 89

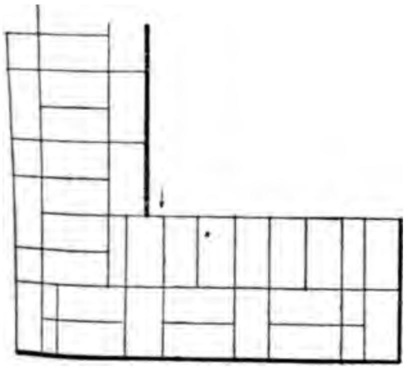


Fig. 88

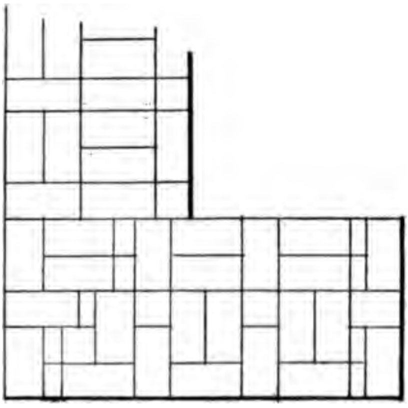


Fig. 91.

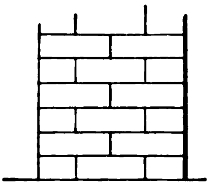


Fig. 90

wall in Flemish bond, from which it will be seen that Flemish becomes very troublesome and weak in thicker walls, as compared with English; the angles having to be tied in with stretchers internally, which is against the rule previously laid down.

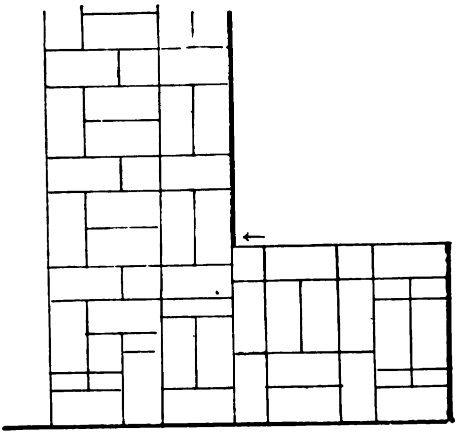


Fig. 92

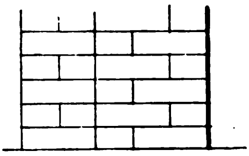


Fig. 93

The modes of treatment and construction for *irregular angles* are dealt with in figs. 94, 95, 96. and 97, which represent 14-inch bay-window angles, in English and Flemish bond respectively. The external angles

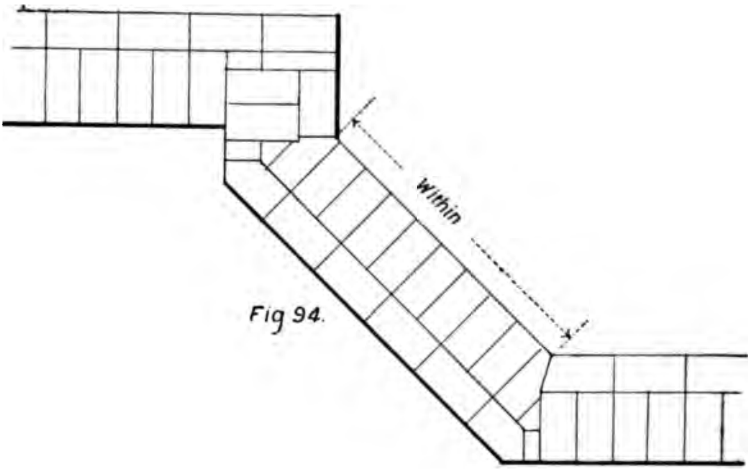


Fig 94.

of these are called *squints*, and the internal *birdsmouths*; the bricks measuring 6¾ and 2¼ inches on the two faces, which are placed alternately; each course with a closer always coming next the 2¼-face in the work, this being equivalent to a header.

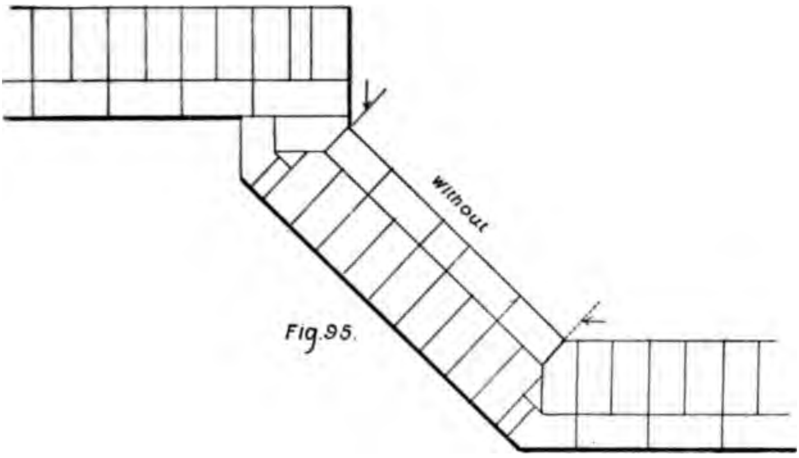


Fig. 95.

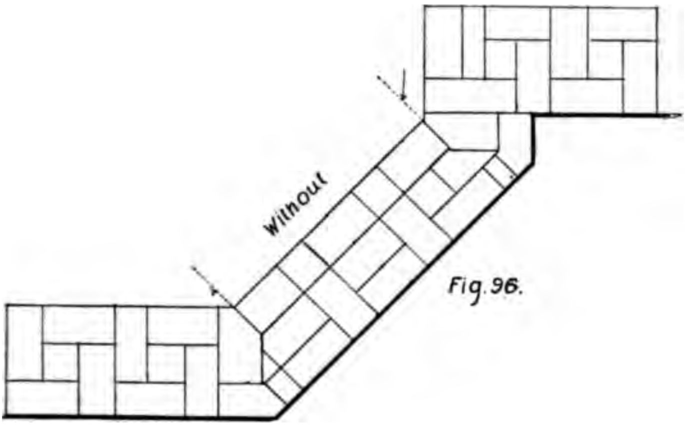


Fig. 96.

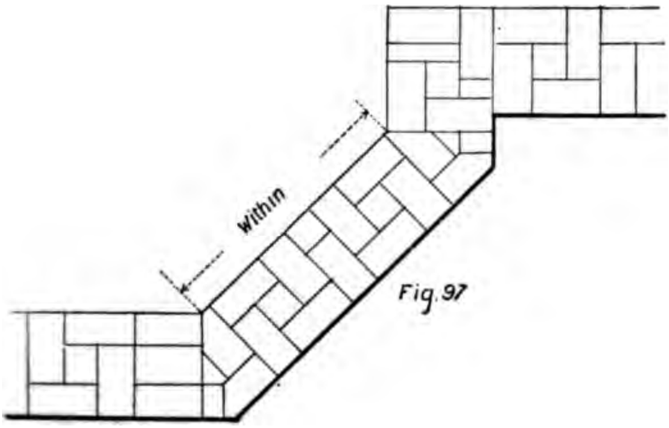


Fig. 97

It will be noticed that the Flemish bond (as figs. 96 and 97) is very inferior and irregular; in fact, there is no regular system about it—no two bricklayers working such angles alike in Flemish bond, the difficulty being in the *internal* work. The only rule that can be laid down with regard to them is that they must be bonded in alternate courses by pairs of headers cut and tied in by the stretchers *within* the angle one course, and *without* the next, as shown in the figures; the same rule, of course, applying to English bond as well; the internal header being placed at the back of the 6¾ face of the squint brick.

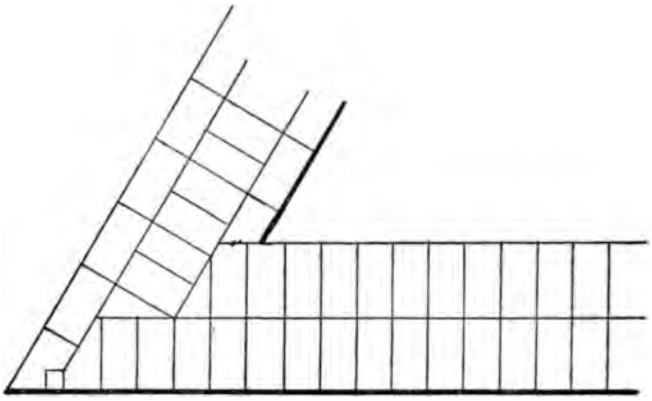


Fig. 98.

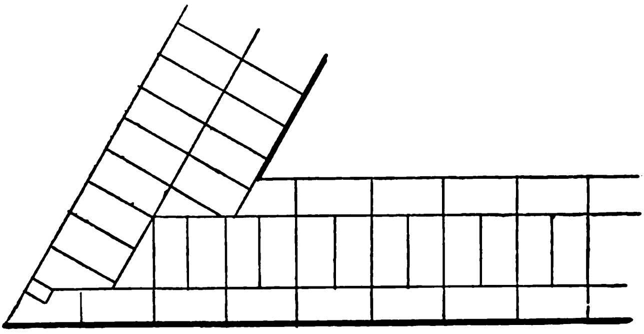


Fig. 99.

In the same way, figs. 98 and 99 represent the methods of treatment and construction for two courses of an *acute* angle in an 18-inch wall.

Intersections of internal and external walls are done very simply, the *internal* wall toothing into the *external* wall 2¼ inches in each alternate course, as in figs. 100, 101, 102, and 103; the joints being broken alternately on the respective courses, as shown by the arrows, and care being taken that where possible each should tie in with a header.

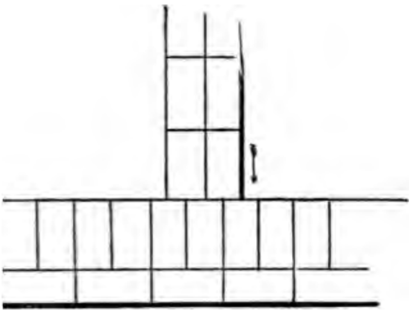


Fig.100.

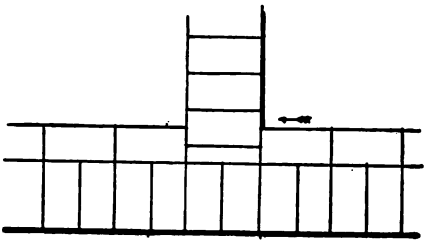


Fig.101.

Brick piers are subjected to the same treatment with regard to the necessary closer at the plumbing angles to break the joint; though it cannot be applied to anything smaller than piers with sides of 18 inches wide or more, in which case they are treated as shown in figs. 104, 105, 106, 107, 108, and 109; from which it will be seen that English alone the bond necessarily used.

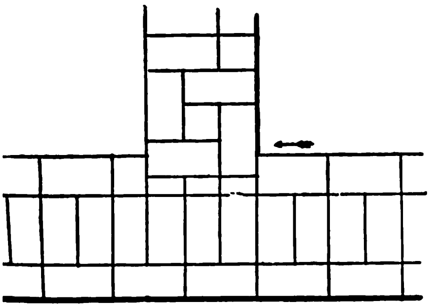


Fig.102.

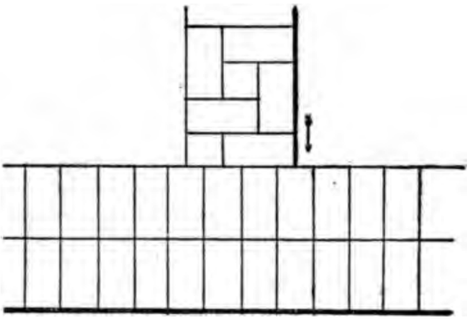


Fig.103.

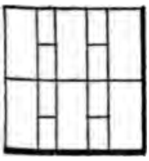


Fig.104.

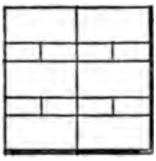


Fig.105

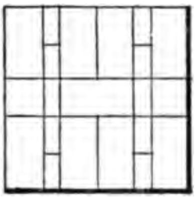


Fig.106.

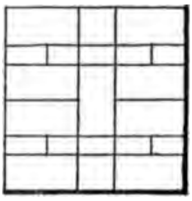


Fig.107.

Sleeper walls supporting ground floor joists are built 4½ inches thick, and about 8 feet apart, to reduce the spans of the joists in big rooms; and they are either built with openings here and there to allow of ventilation, or as fig. 110, which is called *honeycomb* work.

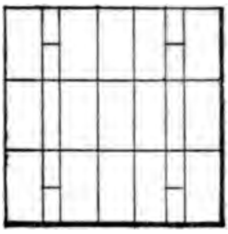


Fig 108.

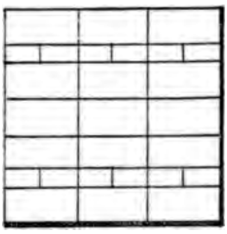


Fig.109

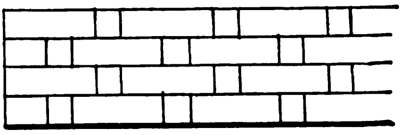


Fig.110.

Fender walls are those built round fireplaces to carry the hearthstones and take the ends of the joists, which would otherwise have to be trimmed.

Brick cores are the irregular-shaped brick surfaces between the tops of flat lintels and the soffits of relieving or discharging arches, as in fig. 111.

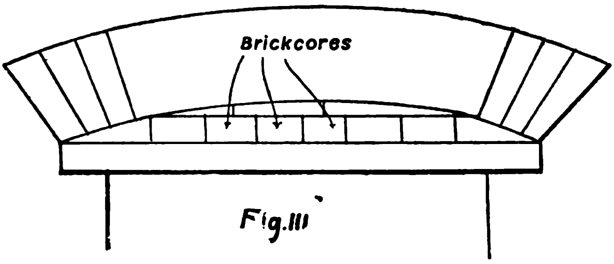


Fig.111

CHAPTER III.

BRICK REVEALS, ARCHES, AND POINTING.

Reveals and their Construction—Forms of Arches—Construction of Arches—Bond of Arches—Pointing—Fireplaces—Flues—Hoop-iron Bond—Wood Bricks and Pads—Brick Corbelling.

Reveals.—A *reveal* is that part of an opening which returns at right angles from the front of the wall—*i.e.*, that part which shows vertically between the necessary angle from the face line and the front of the door or window frame, as in fig. 112, fig. 113 being an illustration of a *splayed reveal*, and fig. 114 a *splayed jamb*, explaining the difference between that and a splayed reveal; the former applying to the *internal* and the latter to the *external* finish.

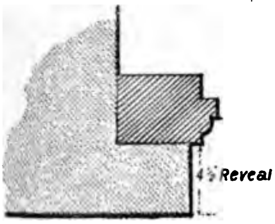


Fig. 112.

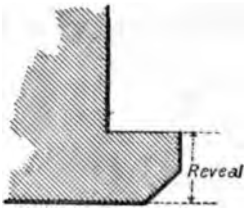


Fig. 113.

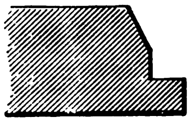


Fig. 114.

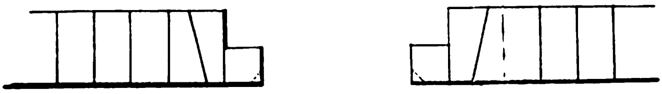


Fig. 115.

Whether a reveal be square or splayed, the student must always bear in mind that a closer must be used on each side of the opening in the same horizontal line in the same course as that in which the closer is placed at the main angles. For instance, fig. 115 represents a square reveal in a wall, in the heading course of English bond, where the king closers will be seen to advantage, fig. 116 being the succeeding or stretching course of the same.

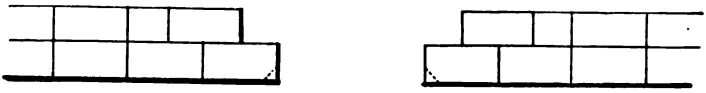


Fig. 116.

It should be pointed out that the setting back of the jamb (or reveal, as it is sometimes improperly called) varies in *width* according to the joinery frame that it has to take, usually being 4½ inches wide for sash-windows, and from 1½ to 3 inches for door and solid window frames.

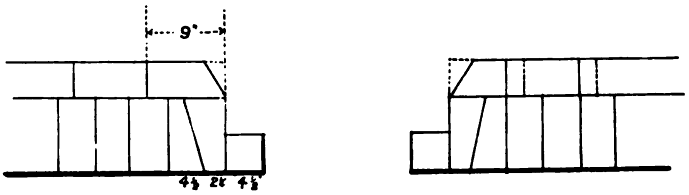


Fig. 117.

It will be obvious that a splayed reveal is made by the peculiar shape of special bricks called *cants*, as shown by the dotted lines to figures; whereas a splayed jamb is generally roughly cut, and worked according to convenience in bonding.

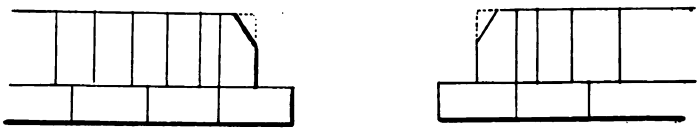


Fig. 118.

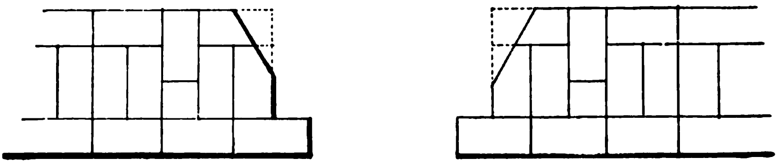


Fig. 119.

Figs. 117 and 118 represent succeeding courses up both window jambs, with a reveal in a 14-inch wall with a splayed jamb, *English* bond; and figs. 119 and 120 that in an 18-inch or 2-brick wall; fig. 121 showing the same, without the splayed jamb; the dotted lines on fig. 119 representing the other course.

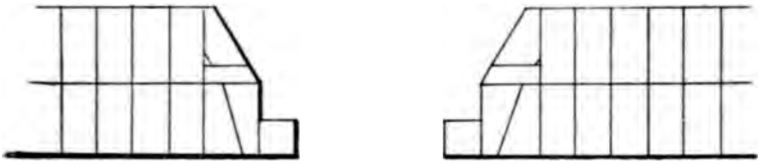


Fig. 120.

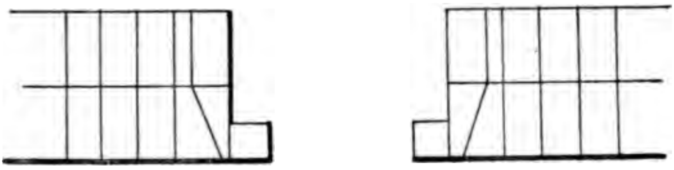


Fig. 121.

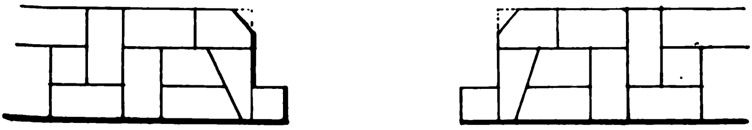


Fig. 122.

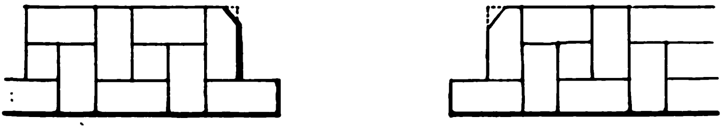


Fig. 123.

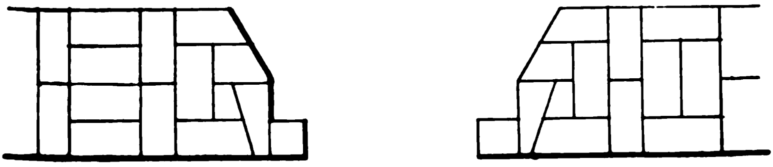


Fig. 124.

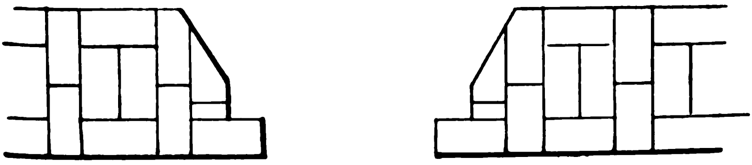
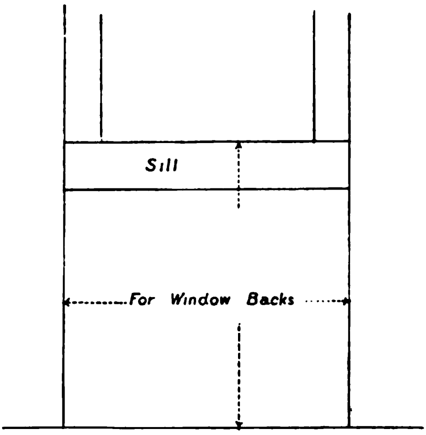


Fig. 125.

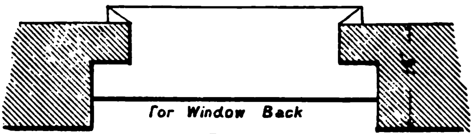
The 14-inch wall, treated in *Flemish* bond, is represented on figs. 122 and 123, and the 18-inch on figs. 124 and 125.

Below the sills the brickwork is often set back within the thickness of the wall, the jambs continuing down to floor-line to allow of window *backs* from window board to floor (as shown on fig. 140), making a 14-inch wall only 9 inches thick below the window sill and between the jambs. *Vide* fig. 126.

Forms of Arches.—An arch is an arrangement of bricks, placed to any shape or curve over an opening, so that each brick is supported by mutual pressure from its neighbours, the whole being wedged in, as it were, over the jambs on each side of the opening.



Elevation.



Plan.

Fig. 126.

Before proceeding to explain the application of bricks to the formation of arches, it will be as well to make the student acquainted with the different parts of an arch, their names, and the various kinds of arches in use.

Fig. 127 is an elevation of a semicircular arch, the capital letters referring to the text with explanations, as follows: *A* represents the *abutments* which support the arch, and from which it springs; they are really the jambs of small openings, and a *pier* will act as abutment to two arches, as shown at *P* on the illustrations: *C* is the *crown or top* of an arch; *E* indicates the *extrados, top, back, or outside*; *F* is the *face*; *H* are the *haunches, sides, or shoulders*, comprising the sides of an arch up to a point halfway between the springing and the crown; *I* represents the *intrados*, *soffit*, *bottom*, *or under-side* of the arch; *J* shows the *jambs or sides* of the abutments and piers; *K* is the *keystone*, or *central voussoir* or *archstone*; *S* indicates the *spandrils*, the spaces over the extrados and haunches up to a line horizontal with the crown; *Sp* is the *springing*, or place from which the arch starts—called *skew-backs* in other than semicircular arches—they radiate to the centre, and form a key to keep the arch in and wedge or tighten it up; *Sn* represents the *span*, or width of the opening over which the arch is built; *Spg* is the *springing or horizontal* line, from which the arch commences; *R* is the *rise* of the arch, from the springing to the soffit of the crown; *V* are the *voussoirs*, *blocks*, *or bricks*, which form the arch, radiating from the centre-point, and supported by mutual pressure from their neighbours.

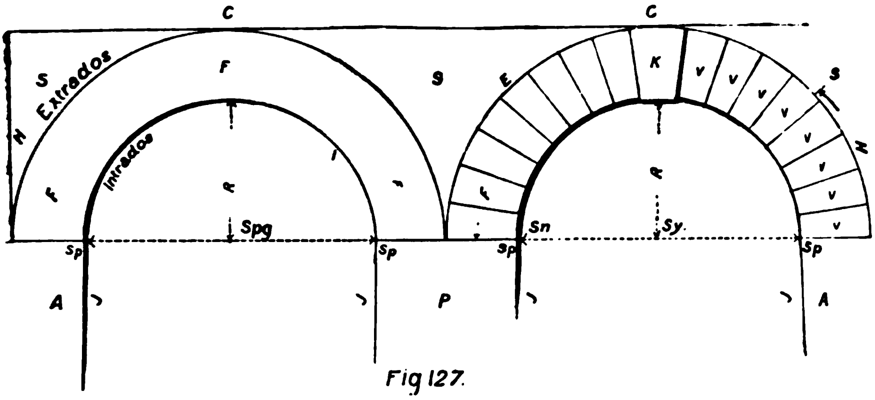


Fig 127.

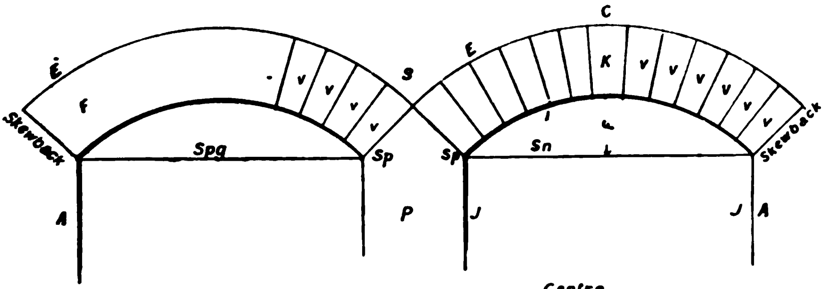


Fig. 128.

Fig. 128 is a *segmental* arch, shown for the purpose of indicating the position of the skewbacks, which do not occur in semicircular arches. The same reference-letters and nomenclature apply as in the last case.

The *semicircular* arch (shown in Fig. 127) is made from one centre situated on the springing line, halfway between the jambs of the abutment. The *segmental or "scheme"* arch (shown in Fig. 128) is formed with a curve which is part of a circle, also struck from one centre, halfway between jambs of abutments, but at a distance below the springing line, which may vary according to the rise of the arch.

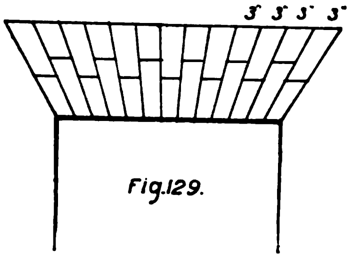


Fig.129.

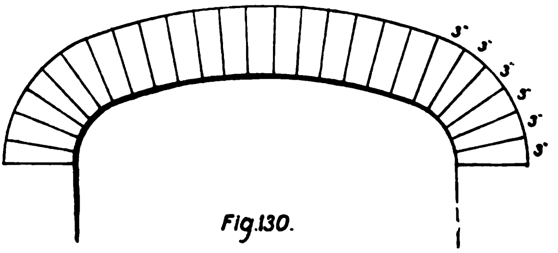


Fig.130.

Fig. 129 is a *straight* or *flat* arch, the bricks (or voussoirs) varying in thickness from a maximum of 3 inches at the extrados to a minimum thickness at the intrados, so as to radiate to a centre below it.

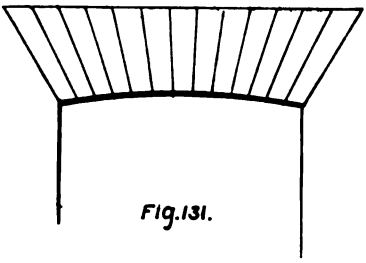


Fig.131.

Fig. 130 is an *elliptic* arch, has half an ellipse for its curve, and is used for wide spans, where only a small rise is obtainable.

Fig. 131 is a *cambered* arch, which is similar to a straight arch, excepting that the intrados or soffit rises slightly in a flat curve towards the centre.

As a rule, in fact, all flat or straight arches should be thus made with a small camber, to allow for settling.

Fig. 132 is an *equilateral* arch—*i.e.*, one whose curves have each an angle of an equilateral triangle as its centre, the two meeting at the third angle. This is also called a *Gothic* arch.

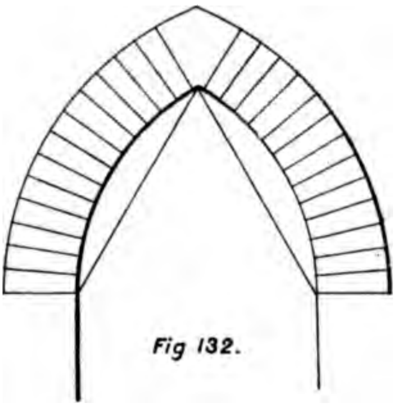


Fig 132.

Fig. 133 represents an arch struck from *three centres*, as shown, and is, as will be seen, akin to the elliptic arch (fig. 130).

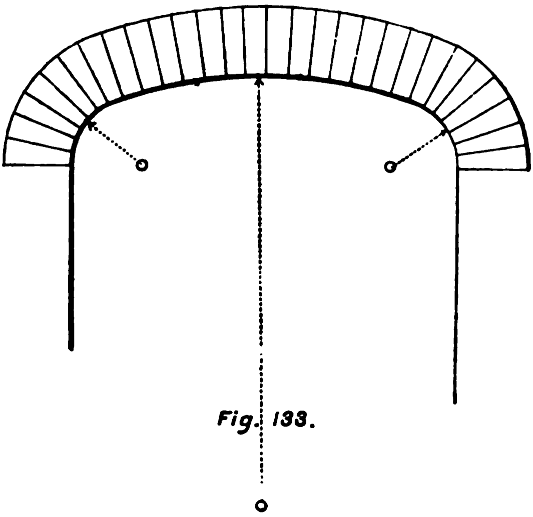


Fig. 133.

Fig. 134 shows an arch struck from *four centres*, and called a *Tudor* arch; being also a *Gothic* arch, but of a later period than fig. 132.

In setting out three- and four-centred aches, the line joining the centres should be at an angle of 30 degrees with the vertical, which can always be contrived by altering the radii.

Trimmer arches will be explained hereinafter, when treating of the construction of fireplaces, chimneys, and flues. *Groined* arches are those which intersect one another at various angles.

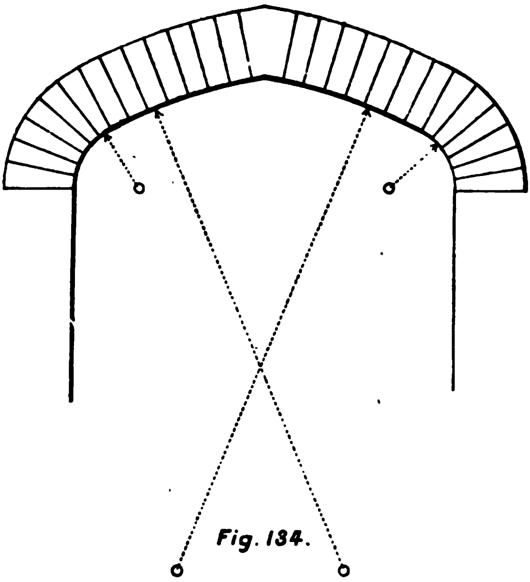


Fig. 134.

Having thus become acquainted with the different kinds of arches, and the names of the various parts, the student will the more easily be enabled to master the constructional points and details.

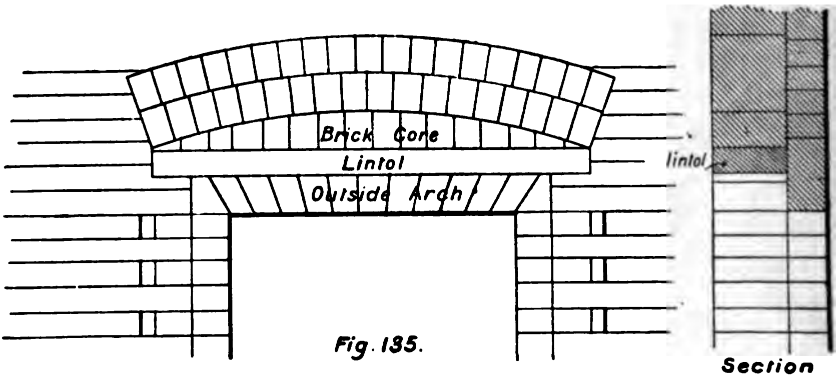


Fig. 135.

Construction of Arches.—The principal kind of arch, most commonly used, is the ordinary brick *relieving* or *discharging* arch, made of rough bricks, over the inside openings of doors and windows and internal openings. It springs from skewbacks outside the ends of lintels,

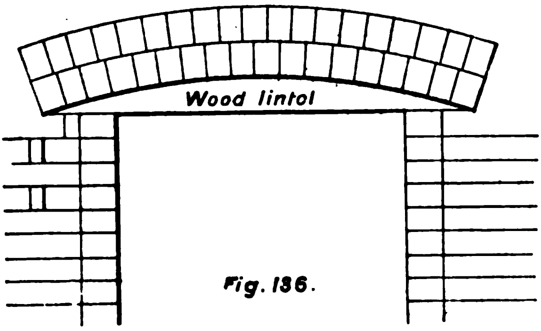


Fig. 136.

and is bedded on a brick core, over the lintel, as shown in fig. 135, or on a circular extrados cut on the lintel, as fig. 136. These relieving arches rise in the centre about one inch for every foot of span.

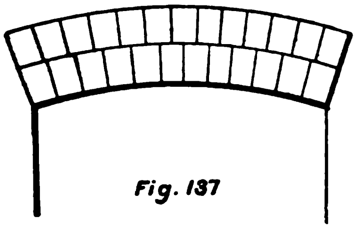


Fig. 137

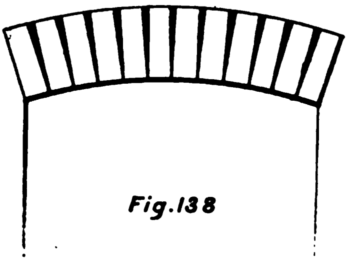


Fig. 138

Such arches, of a very small span and of a considerable rise, are built up in half-brick rings, as shown in fig. 137, in order to obviate the excessively large joints, which would result from the use of whole bricks, at the extrados, as shown in fig. 138.

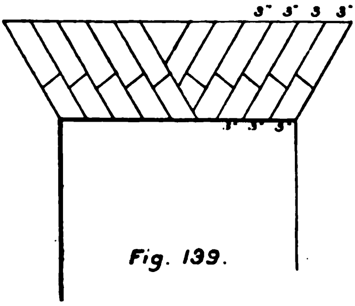


Fig. 139.

French or *Dutch* arches are flat or straight, as shown in fig. 139, differing from fig. 129.

Other kinds of arches are built on temporary wooden framings or centres of the required dimensions and curves, to support the brickwork until it has settled into its proper position, and become duly bound together and solidified by the setting and hardening of the cement or mortar.

The commonest arch of this class, which requires centres, is the *French* or *Dutch* arch. This is a rough flat or cambered arch, but distinct from the ordinary flat arch (fig. 129), by a different mode of construction in regard to the arrangement of the bricks, as appears from fig. 139; but, from its unsightliness, it is only suitable for walls which are to be plastered or otherwise covered up.

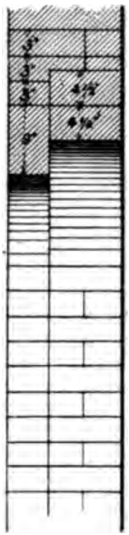
All the different kinds of arches can be built, either rough for plastering, with the ordinary common bricks, or they can be axed or rubbed and gauged for facework, as hereinafter explained; and all such arches should be built in cement, for the best work.

An *axed* arch is one formed of hard bricks, which are cut, either roughly or finely, by the bricklayer's axe, to the wedge-shaped size and shape required.

Rubbed and gauged arches are built of "rubber" or other soft bricks, which have been cut and finely rubbed to the form and dimensions required. They are usually set in "putty," with very fine joints; and care should be taken that the joint of each brick is perfectly true, and at right angles with and within its face; so that the pressure may be equally distributed, and the edges of the bricks not liable to crack and split away from any undue pressure at the outside, where they are bound to show a line. Some arches are built with special-made bricks of the required wedge-shape and size.

The student will notice that, in openings with rubbed or axed arches outside and a rough arch inside, the inner arch is to be set back to the full depth of the jamb, outside the line of soffit of the outer arch as shown in figs. 140 and 141; or as already shown in fig. 135, when applied to lintels and discharging or relieving arches. There is only one, difference by which the various kinds of arches can be distinguished on drawings, *common* brick arches showing thick wedge-shaped joints, and each brick measuring 3 inches at the intrados, while the bricks in both *axed* and *rubbed and gauged* arches show 3 inches on the extrados; and the difference between the two is further shown by two grades of the lines, thin lines indicating the superior kind, while the thick lines denote common work.

Inverted arches are those turned upside down, for the purposes of spreading the weights and pressure from piers, and in special places, on to a wider area of foundation; as in such instances as big chimney-breasts and arcades, shown in fig. 142.



Section
Fig. 141

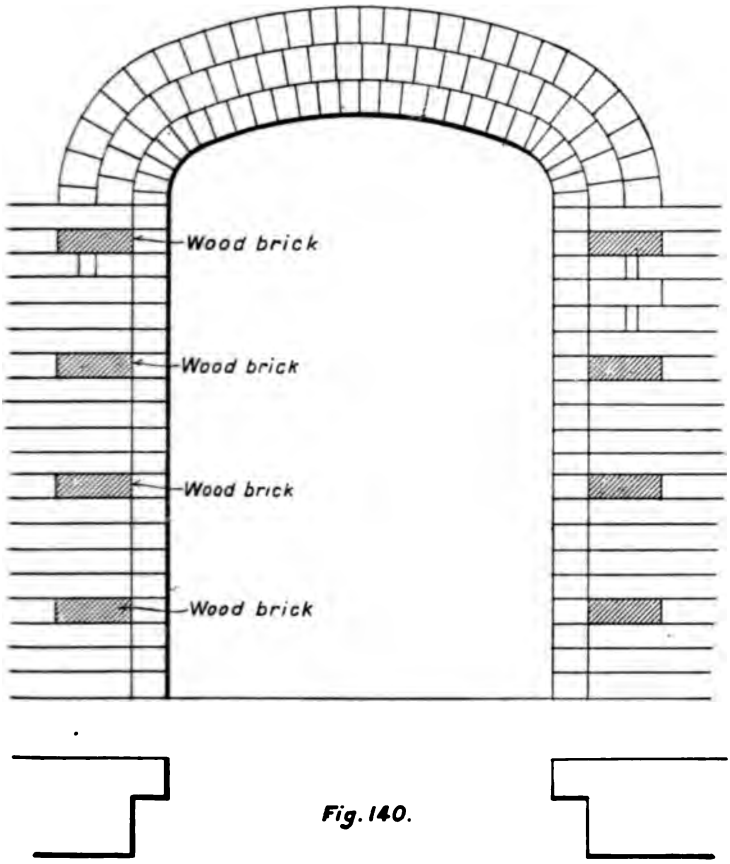


Fig. 140.

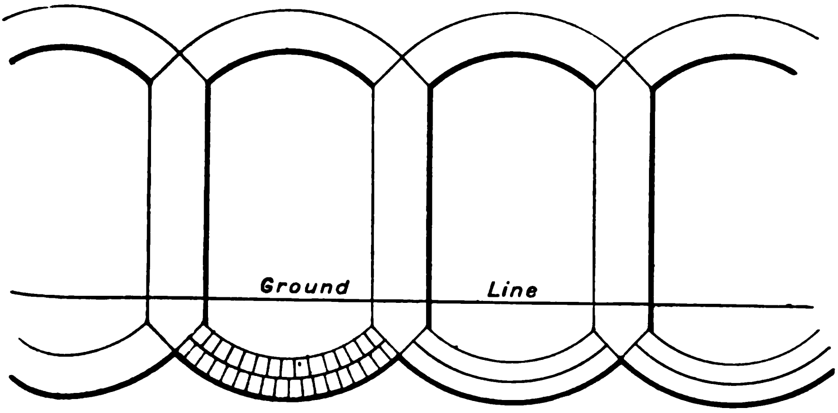


Fig. 142.

Bond of Arches.—The bond of arches is not generally so intricate as that of walls, etc.; though there must necessarily be some system of binding the component parts together. Before entering into this subject, however, it is necessary to point out that brick arches are described by the number of rings or half-brick rings in which they are built—a ring indicating a course of the arch struck from the centre.

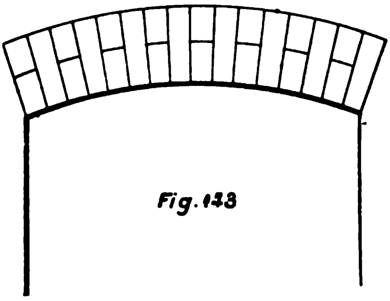


Fig. 143

English and Flemish bond, in arches formed of a single-brick ring, are alike in elevation, being similar to fig. 143, the usual well-known difference only occurring in the arrangement of the bricks from the face as appearing on the soffit; fig. 144 being the plan of the soffit (as seen from underneath) of an English bonded arch; and fig. 145 that of Flemish bond.

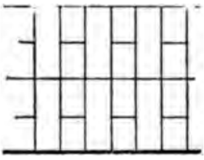


Fig. 144.

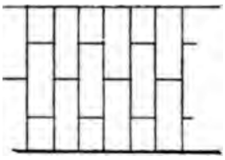


Fig. 145.

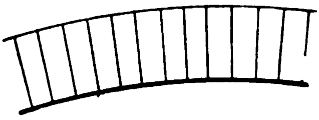


Fig. 146.

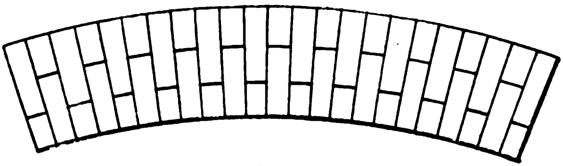


Fig. 147.

Heading bond, in an arch of a single-brick ring, is illustrated by fig. 146; but the most practically bonded arch (which has also the best appearance) is the brick-and-a-half-ring arch shown in fig. 147.

Half-brick-ring arches, such as that depicted in fig. 148—formed of several half-brick rings—show a finer joint, with less labour, and they are the most easily built; but in big spans the rings are apt to separate from each other at the coursing joint, from want of bond. This absence of unity and solidity frequently becomes a source of weakness; and in order to guard against such defects in heavy arches, a few courses must be bonded occasionally, when the heading joints which radiate are in line so as to allow of it, as in fig. 149, for half-brick rings; but a more complete and stronger arch than this can be made by superseding the half-brick ring entirely, as shown in fig. 150, for an 18-inch or 2-brick arch.

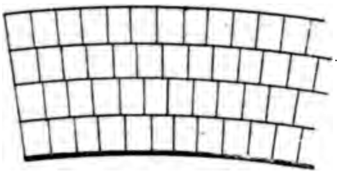


Fig. 148.

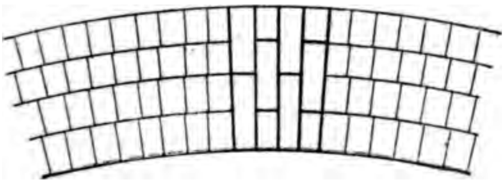


Fig. 149.

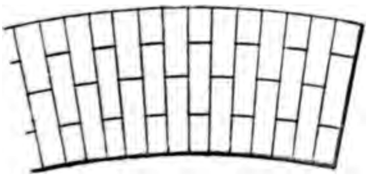


Fig. 150.

Larrying, as applied to brickwork, is the term used for pushing up the bricks within the outsides of thick walls into their position, collecting mortar to form the joint, as they go along, from a rough quantity that has been thrown in.

Grouting consists in pouring mortar (of the consistency of cream) over the top or last course of three or four successive courses which have not been properly jointed. The semi-fluid mortar runs into all crevices that may have been left, and forms the whole, when set, into one solid mass.

Dinging is the term used to describe the brushing over of the brickwork with a wet brush while the mortar is damp after being "struck fair."

Wigging is a term employed in Dublin to denote the facing treatment applied to the rough bricks used there, the vertical joints being filled up with blue mortar and the horizontal ones with red, the whole being afterwards pointed with a white cut joint.

Pointing.—"Pointing" is the finishing off (with the trowel) of the mortar in the rough joints between the bricks, so as to give the work a better appearance on the face; and the stipulation should be specified, that no four courses of 3-inch bricks should exceed 13¼ inches in height when laid.

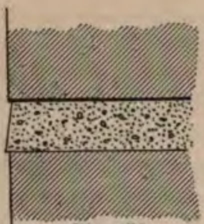


Fig. 151

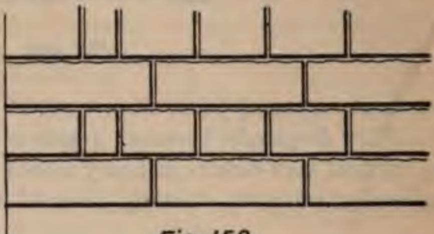


Fig. 152.

Figs. 151 and 152 represent—in enlarged sectional and front view respectively—*struck-joint pointing*, or, as it is also called, *broad pointing*, in which the mortar is pressed in with the trowel.

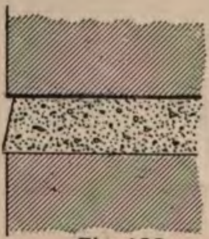


Fig. 153.

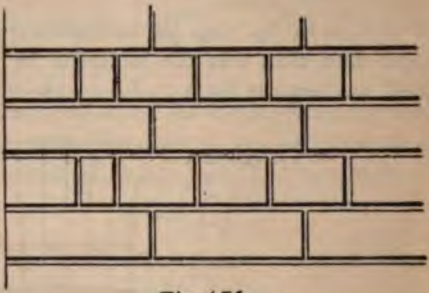


Fig. 154.

Figs. 153 and 154 show, similarly, the latter, when the joint is cut with the trowel on the bottom edge, called *cut* pointing. It has a better effect than that shown in fig. 151, and it has a cleaner and sharper appearance, the bottom edge of the mortar being cut to a horizontal line.

Figs. 155 and 156 explain in like manner *weather*-pointing, which is done with the trowel, the upper edge of the mortar, under the bottom of the upper brick, being pressed in.

Figs. 157 and 158 also represent a *rule* joint, the mortar being pressed in with the trowel; and then a jointer of thin bar-iron, bent to the form of an S, is run along the middle of the mortar to press it in a horizontal line, being guided by a straight-edge or rule laid along the joint, on which the S-jointer travels. The dark horizontal lines left by the jointer give the work a better and more finished appearance.

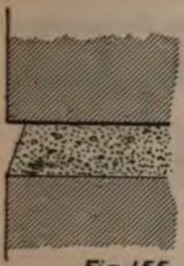


Fig. 155.

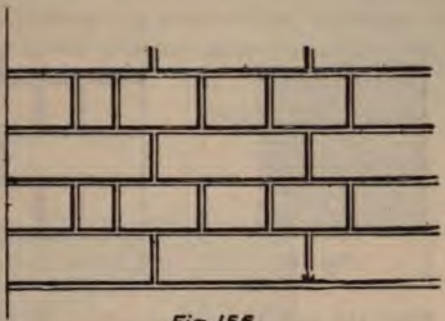


Fig. 156.

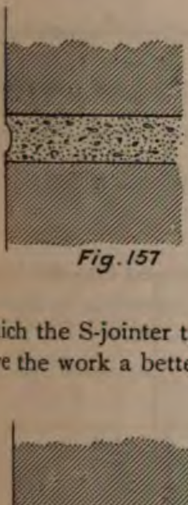


Fig. 157

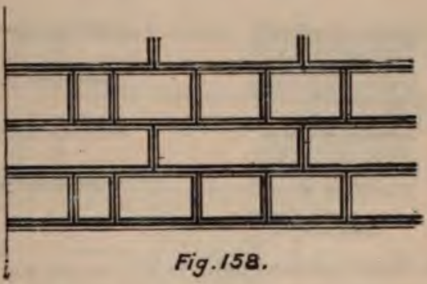


Fig. 158.

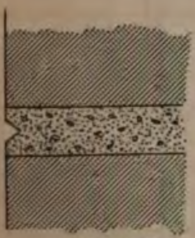


Fig. 159.

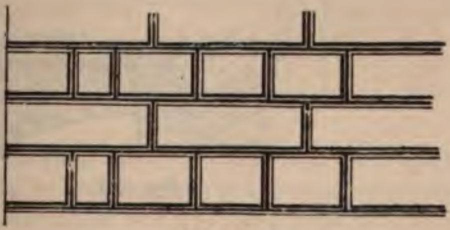


Fig. 160

Figs. 159 and 160 illustrate *V-pointing*, which is done similarly to the last described, but with the jointer pointed to leave an impression like a *V*.

Figs. 161 and 162 represent *beaded* pointing, the work being done just as the two last-named, but with the jointer made to impress a bead on the joint.

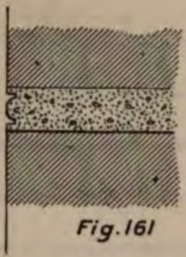


Fig. 161

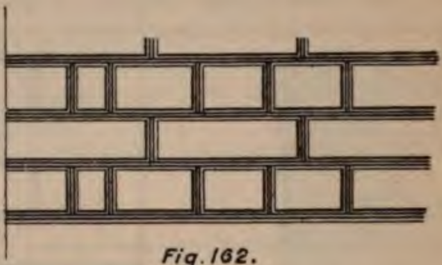


Fig. 162.

Figs. 163 and 164 are examples, in the same way, of *tuck*-pointing. In this mode of pointing, after the ordinary mortar has been pressed into the joint or scraped out, and the joint stopped up flush with mortar the colour of the bricks, a straight-edge is laid horizontally along the joint, and

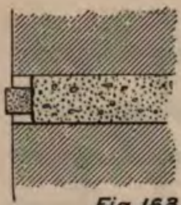


Fig. 163.

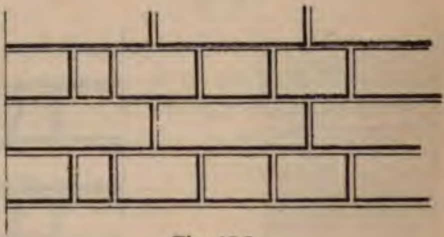


Fig. 164.

thin white-coloured putty is laid on the top of it and pressed into the joint, after which the top edge is cut off level, leaving the projection as shown. The vertical joints are, of course, done in the same way.

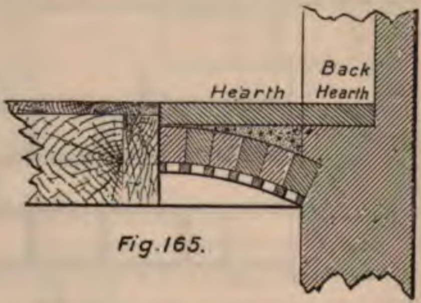


Fig. 165.

Fireplaces.—As fires are a source of danger to a building, which must necessarily have some wood floors, it becomes essential that some means should be employed to reduce those risks to a minimum, and with that view *trimmer* arches were devised for wood floors with ceilings under them. The joists are framed round the chimney breast (as is explained in Chapter VIII.), and the open space left in front of the fireplace is filled in with brick-arching 4½ inches thick, springing from a skewback cut into the breast of the chimney, above the ceiling line, to

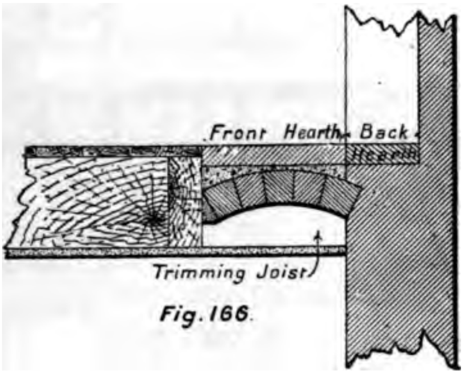


Fig. 166.

he trimmer-joist, as shown in fig. 165, and resting on light centring, which is left in for the purpose of carrying the ceiling-lath underneath.

Another method is shown in fig. 166, a feather-edged wood springer being nailed to the trimmer-joist, and the arch springing from both sides

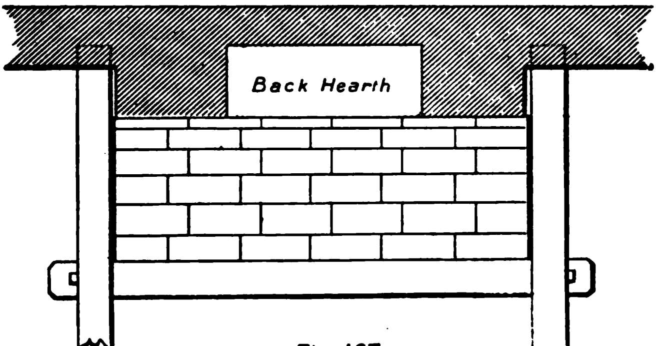


Fig. 167

instead of from only one (*i.e.* the wall), as shown in fig. 165. The spandril above this trimmer-arch is filled in with concrete, and levelled up to receive the tiles, cement, or hearthstones about 2 or 2½ inches thick, as shown on the sections. The plan of the hearth, etc., is as shown in fig. 167, which shows the trimmer-arch under the front hearth to be 14 inches wider on each side of the jambs of the fireplace, and to project 14 inches outward—though 18 inches would be better. Certainly it should project no less than 14 inches, and be no less than 9 inches wider on each side of the fireplace jambs.

Ground-floor fireplaces, in stone or brick-paved compartments, require no special provision for safety from fire; and those with wood floors have their hearths as for the upper floors; but, instead of being supported by trimmer-arches, they are secured by sleeper walls enclosing the usual space filled in with concrete, as explained by fig. 168.

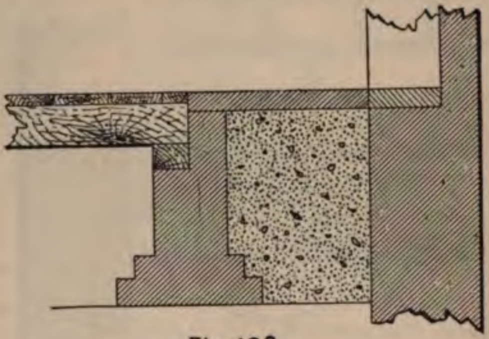


Fig. 168.

Fireplace openings are generally arched over on a 2½ in. by ⅜ in. wrought-iron chimney-bar, curved to the form required, and with the ends going 9 inches into the breasts, split and turned up and down to keep them in, as seen in fig. 169. At the back of this the jambs are gathered over, by 2¼-inch projections, to the size of the flue; and in best work a York-stone slab is generally placed on the top course to act as a *ledge* to stop down-draughts of *wind*. This construction is delineated in fig. 170. When

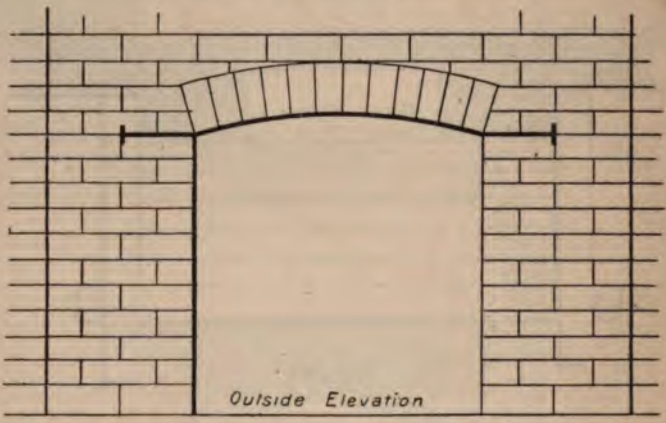


Fig. 169.

ar fireclay flue-pipes are used to line the flues a special-made radiating ig. 171) is used to gather the opening over to the size of the flue.

; to the construction of the flue itself, after the brickwork has thus gathered in or collected to the flue, it must be impressed on the it that no flues should be made of less dimensions internally than 4 inches, and they may be made as large as 18 by 18 inches, though ssential they should be of the same size exactly throughout. They l, however, not be built straight all the way up, but diverted, in one another, as much as possible, as a good, well-constructed flue should ow daylight at the top to be visible to any one looking up from the ce. The necessary arrangement of a breast and stack of several eys will be understood from figs. 172, 173, 174, 175, 176, 177, and presenting complete plans and sections of a large chimney-breast.

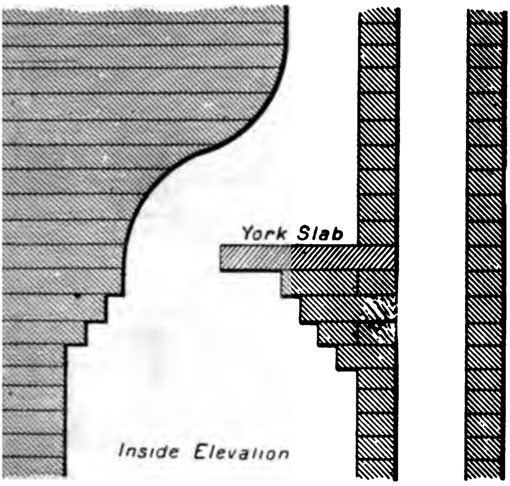


Fig. 170

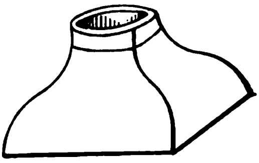


Fig. 171

e supplementary fig. 179 is an enlarged detail-section of the breast, 1 the uppermost floor, and fig. 180 is a section through a cottage, g how flues are, from separate chimney-breasts, sometimes brought er.

es.—Flues should be *cored—i.e.*, tested for their uniformity, and all tion cleared off; and the interior surface must be smoothly *parged eted*, or covered with mortar mixed with cowdung, to prevent crack- the inside flue-faces may be built in smooth regular bricks, and neatly inted in cement mortar—a process which has an advantage over

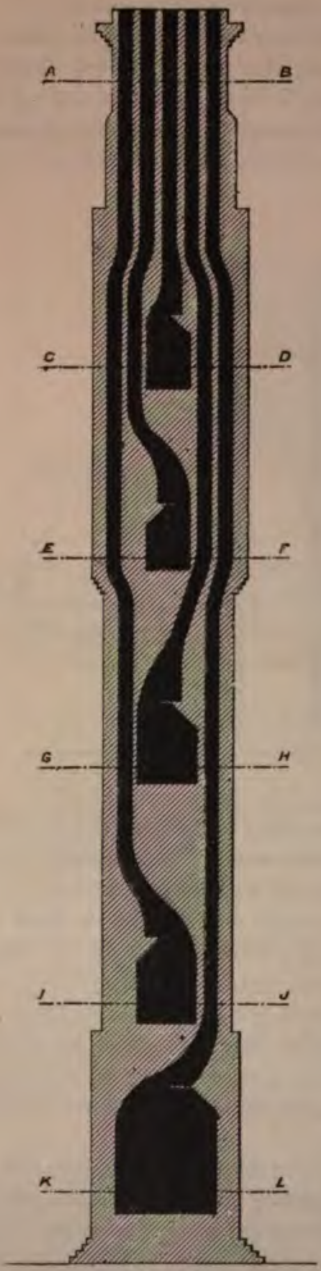
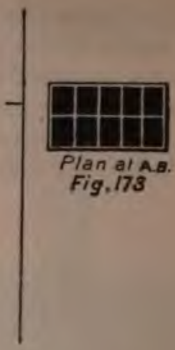
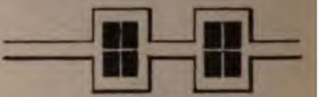


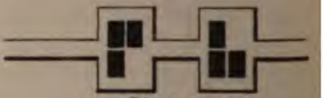
Fig. 172



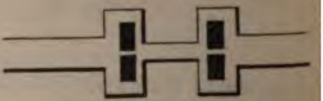
Plan at A.B.
Fig. 173



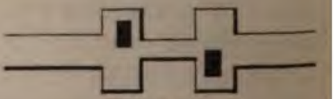
Plan at C.D
Fig 174.



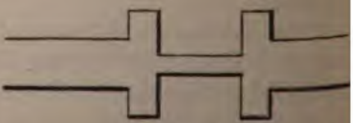
Plan at E.F
Fig. 175.



Plan at G.H
Fig. 176.



Plan at I.J.
Fig. 177.



Plan at K.L
Fig. 178.

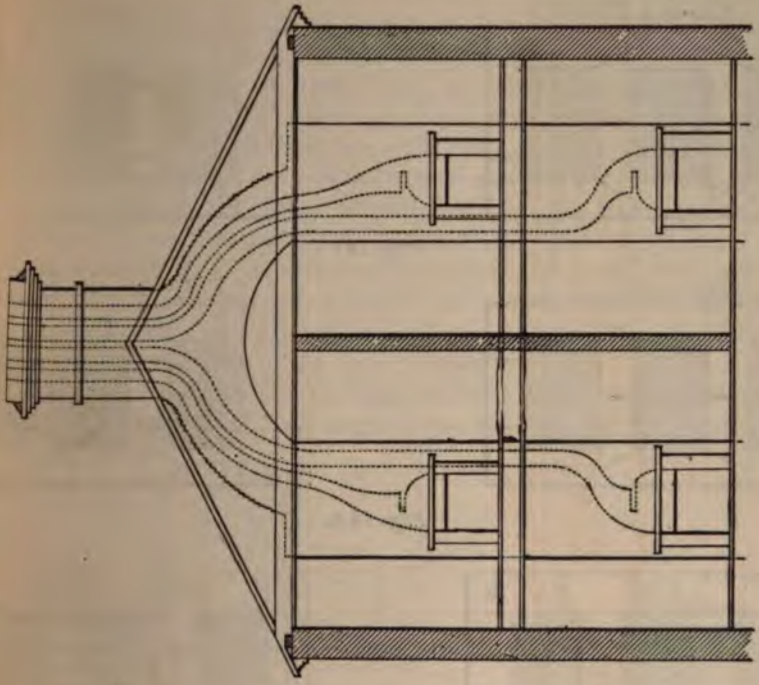
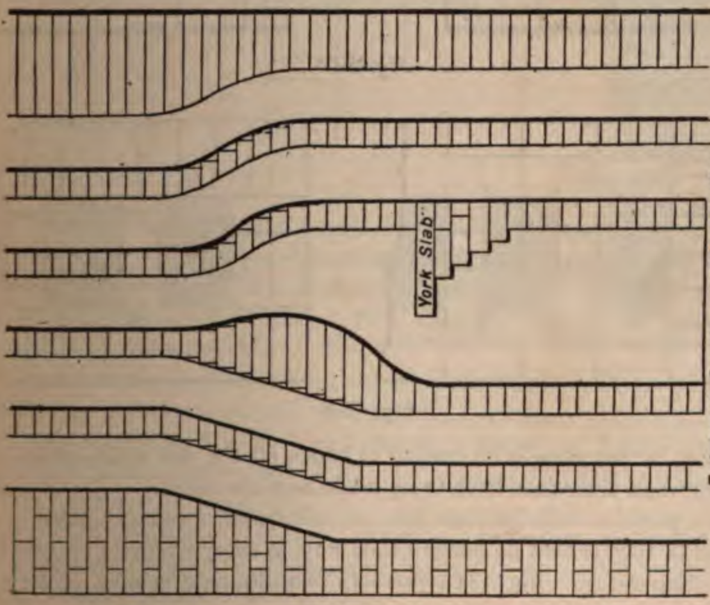


Fig. 180.



Enlarged Section at C.D. Fig. 172.
Fig. 179.

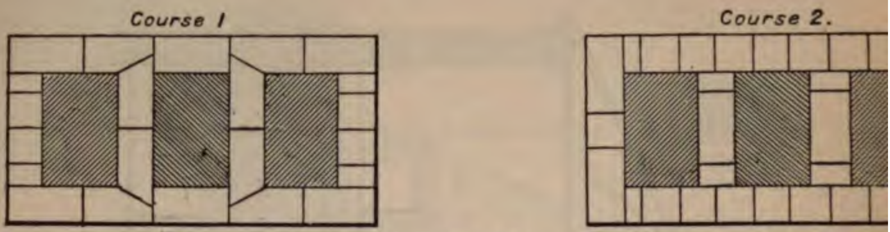


Fig. 181

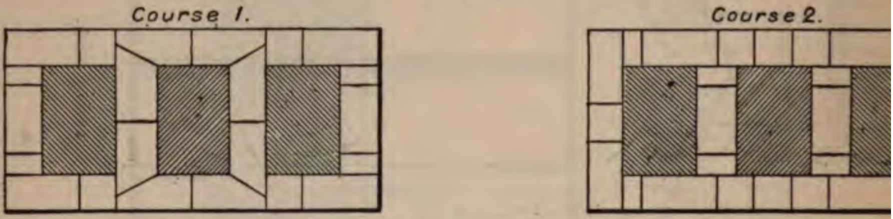


Fig. 182.

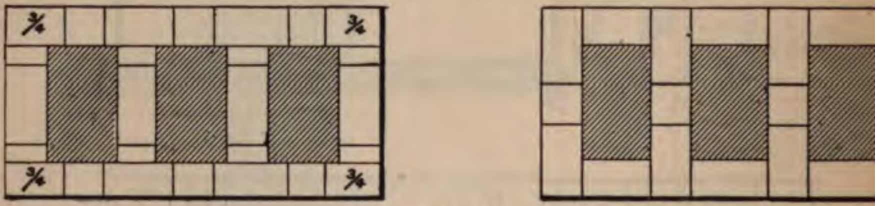


Fig 182A.

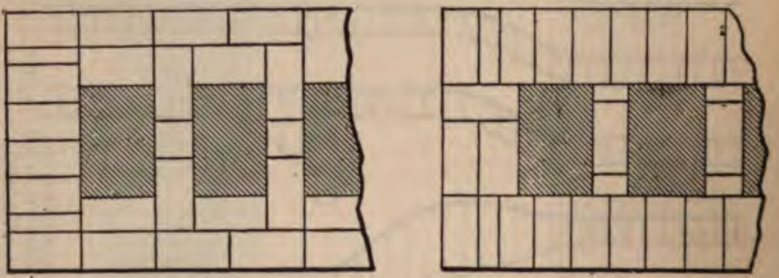


Fig. 183.

pargeting in that there is no coating to knock off the flue-walls, which may happen when alterations have to be made next the flues.

The partition-walls between flues are called *withes*, or *mid-feathers*; and, of course, they should be bonded each way, at every alternate course, into the outside casing. Fig. 181 represents two alternate courses of English bond, ½-brick thick, and fig. 182 those in Flemish bond, while fig. 183 shows that there is practically little difficulty in bonding the withes into 9-inch outside walls of whatever bond; fig. 182A showing a much-used arrangement which has its advantages, although not strictly Flemish bond.

The *caps* of chimney stacks are made more or less ornamental by the use of moulded bricks or terra-cotta, but more commonly by means of several *oversailing* courses, projecting or corbelling out one above another, as shown in fig. 184, and mitring at the angles, or returning all round the chimney, and finished off with a chimney pot. The top courses should always be set in cement; and it should be here remarked that no corbel or oversailing brick should project more than 2¼ inches at a time, just as offsets and all projecting bricks should be headers.

Hoop-iron bond, which has superseded the use of longitudinal bond-timbers, consists of thin long strips of wrought-iron, about 1⅛ inches by 1/16 inch laid and built in along the walls, between the courses, in rows at every two or three feet in height above head, and below sills of window, and turned at the ends up joints to assist in preventing rupture of the brickwork horizontally from unequal settlements. It is often specified to be tarred and sanded before being built in.

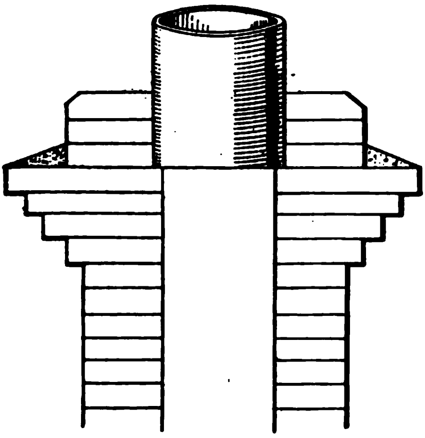


Fig 184

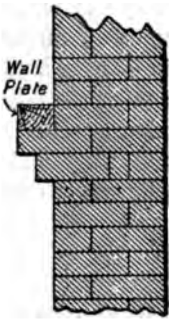


Fig. 185

Wood bricks are often built in jambs for fixing joinery work to; though they are now generally superseded by breeze and patent bricks, which are fireproof. *Elm pads*, 4½ inches by 9 inches by ¼ inch, are also used for the same purpose, and built in the joints, sometimes vertically, for the attachment of skirtings, etc.

Brick corbelling is a series of projecting bricks, for the purpose of giving additional support to, or to carry, wall-plates and other projections over plain walls below. *Vide* fig. 185.

CHAPTER IV.

DAMP AND ITS PREVENTION.

Danger of Damp—Protection below Ground—Protection above Ground—Prevention of Damp Rising—Prevention of Damp Descending.

Danger of Damp.—The chief, if not the greatest, enemy of the builder is damp. It will ascend, descend, and penetrate—*i.e.*, attack materials in all directions; and wherever it makes—or is allowed from inattention, carelessness, or want of forethought, in the first instance, to make—an inroad, it brings ruin to the building itself, in every manner, by sowing the seeds of decay; ruin to the furnishing and finishing of the building; and oftentimes ruin to the health of its occupants. Therefore it is the duty, and should be the chief care, of the builder to keep damp out, by one or other of the various means which will hereinafter be pointed out and explained.

This duty generally falls to the bricklayer and mason, except in so far as roofing is concerned, when it devolves on the carpenter, plumber, and slater; and all these will be dealt with, respectively, in their proper places. The bricklayer, however, is often really responsible for the decay of the carpenter's work from damp; though it should be the business of the latter, when possible, to see that due precautions have been taken with the brickwork before he puts in the woodwork which it is his business to attend to.

Protection below Ground.—There are numerous methods of preventing the penetration of damp through the enclosing walls into apartments below the ground line:—

1. By building the walls of *greater thickness*, and setting the bricks in cement—a simple method, but often rather expensive; and, moreover, on valuable sites, a considerable quantity of room is sacrificed for this purpose, as compared with another mode of prevention which could have been used to greater advantage.

2. By *hollow dry-area walls* around the external faces, as illustrated

by the section Fig. 186. This also is disadvantageous, for the same reason as method No. 1; and, in addition, care should also be taken that the cavity is thoroughly well ventilated, so as to maintain a current of air always passing through every part of it. Moreover, while providing such free and ample ventilation, every precaution must be taken to prevent any vermin harbouring in this cavity, as well as the accumulation of any refuse therein. The open area should commence from the footings, the bottom being paved in cement, and its walls built battering, in cement, from the bottom; and it should be wide enough to allow of its being cleaned out, when requisite. The top should be covered over with York slabs well secured together; or it should be arched over, as shown by dotted lines, which also is often done, in addition to the slabs. Through ventilation should be secured by ventilators at the top and bottom, the holes of the gratings, of course, being made very small in order to keep out vermin.

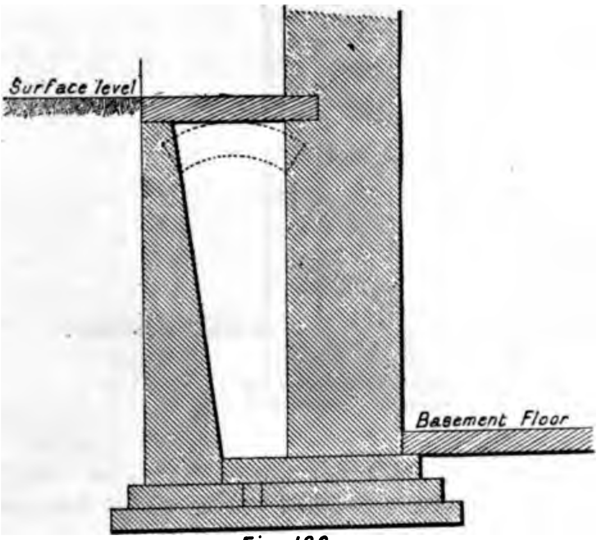


Fig. 186.

3. By lining the inside with a *thin brick wall in cement*, with a small *cavity* left between it and the main outer wall, as shown in fig. 187. This also takes up room, but otherwise is a good remedy. It is usually adopted for thick rubble stone walls, which are sometimes tarred before the brick-lining is built up securely, and free from ventilation. This method has the advantage also of being applicable to rooms above the ground floor line. The heading and bonding bricks should have their ends (which go into the stone wall) well tarred before being built in.

4. Another method is to run *Hygean Rock asphalte*, while hot, within the vertical joints of the enclosing thick walls. This is usually done about half a brick or 4½ inches from the external face, the first vertical joint inwards, longitudinally, being left open, as shown in fig. 188. The asphalte is poured in at every three or four courses, filling up the crevice, and forming a complete coating inside the wall. This is a cheap method, but it is only applicable with advantage to brick walls; still, it is very effectual, and also very convenient and useful for the upper part of the wall.

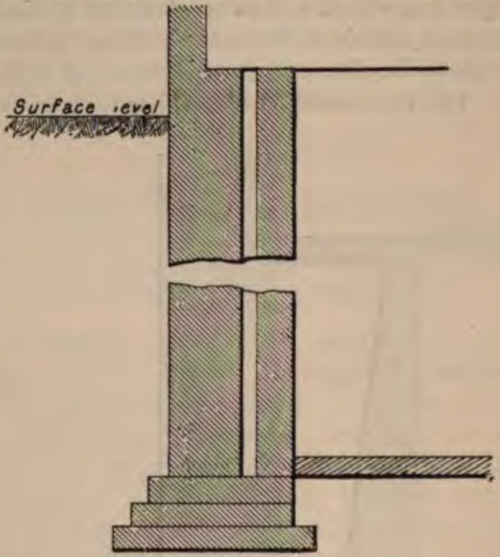
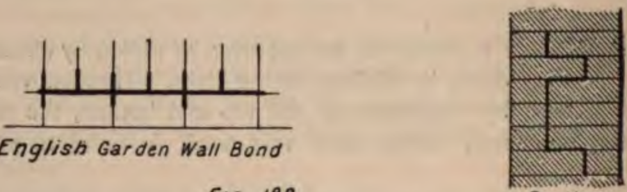


Fig 187:



English Garden Wall Bond

Section

Fig 188.

5. To face the wall externally with *blue-brick work*, built and bonded in cement. This has been proved to be a simple and effectual remedy against the penetration of damp.

6. To render the *external face over with cement and sand*, about one inch thick. This is another simple remedy, which can be used both above and below the ground floor line; the upper portion admitting of treatment ornamentally, without any great expense.

7. The outer faces of the basement walls can also be coated with *asphalte*, laid on hot, about three-quarters of an inch thick; which, though very expensive, is the most effectual method of preventing the penetration of damp. Seysell and Val-de-travers asphaltes are the best for this purpose, and should be laid on by the company's own men.

Protection above Ground.—The walls of rooms above ground-line are protected from damp by the following methods:—

1. The use of the *Hygean Rock composition* (as before mentioned).
2. The *cement rendering*.
3. *Blue brick* facing (also as previously explained; though the latter is not very bright and pleasant-looking to the eye).
4. Building the walls *hollow* with the "thick skin," as it is called, either inside or outside; the two being bonded together (*a*) by the use of galvanised iron wall-ties (*vide* fig. 189); (*b*) by the patent vitrified bonding bricks, as shown in fig. 190. The outer skin (about 4½ inches or a half-brick thick) is built up—with a 2-inch cavity, ventilated at top and bottom for the circulation of the air, which is a non-conductor—simultaneously with the inner or thicker portion, about five bonding bricks or ties being used to each superficial yard—about twelve inches apart in height, and from two to three feet horizontally. Thin strips should be used during construction, in order to keep the mortar from falling inside the cavity; or sand courses may be left at the bottom, to allow of its being cleaned out when finished; though this latter method is not so good, from a practical point of view, for the stability of the work.

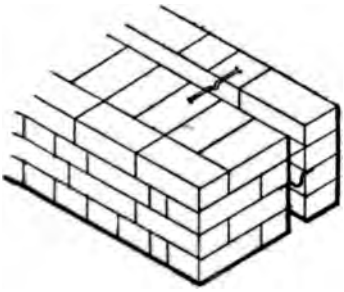


Fig 189

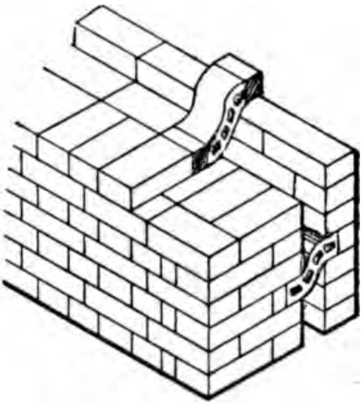


Fig. 190.

It is, however, to be noted also that hollow walls are a source of trouble, wherever openings occur, especially at the heads; the jambs being easily got over, as shown at fig. 191. The heads, or lintels over the heads, in hollow walls are unprotected against all possibility of wet falling on to their upper surfaces. The best way to guard against this source of weakness, in good work, is to lay thin sheet lead (formed into a gutter) over them, between the joints (*vide* fig. 192), and having a fall both ways from the centre of the lintel, so that the wet is carried and thrown off them by the gutter, which should project two or three inches beyond the end of the lintel.

It is better to have the thin skin at the outside, and the thicker (or main) walls inside; inasmuch as the penetration of damp is all the sooner stopped by the circulation of the air in the cavity, and there is then a thicker dry wall inside. This, in fact, is the strongest, best, most advantageous and economical system; as, with the thin skin inside, all joints, roof, and other bearing timbers can only get a bearing of 4½ inches, on a half-brick wall, which is not sufficient, as the 4½ wall is not strong enough to carry the whole weight of the building; hence all such bearings have to be of increased length to go into the outer wall, which, though it is the thicker and stronger, is also more exposed to damp.

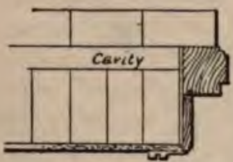


Fig. 191.

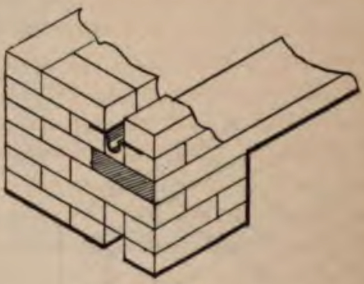


Fig 192.

Bridging over the cavity at these points of support may be recommended as a remedy, to avoid that increased expense; but, obviously, that would be to do away with all or most of the benefit, for the attainment whereof the hollow wall had been employed; seeing that it would break the *non-conductor*, and the damp would be transmitted from the outside to the inside wall by the bridge.

5. The external face of the walls may be *slated* or *tiled*, to wood laths nailed to bond timbers on pads built in as the work proceeds. If slates be used this method gives the building too much of the appearance of a roof, and creates a dull and uniform monotony of colour. When tiles are used, which may be of a different and lighter colour, and varied in form, they can be treated ornamentally, which cannot be done with slates; and to obviate the use of wood battens and plugs thin Wright's breeze-

fixing blocks are built in, alternately with every brick course, having a slight projection on which the nib of the tile rests, while the tile itself is nailed to the blocks which are the "gauge" from centre to centre, two courses of blocks and one of bricks replacing two ordinary brick courses.

6. The outside of barns and other unimportant buildings are often *coated with tar* to keep out the damp.

Of the means used to stop damp where it has penetrated the walls of a building, Szerelmey's solution is one of the best, a coating or two of the solution (either applied internally or externally) often completely stopping it and rendering the wall water- and damp-proof.

Blundell's petrifying liquid is also a good remedy, and can be applied in various colours, which, having a glassy surface, can be readily washed. The walls can also be covered with Willesden paper, which is said to be water- and rot-proof; or they may be papered with laminated lead or tinfoil papers before the decorative work is applied. If the walls are very damp, it may be advisable to plaster the walls in Portland cement instead of the ordinary materials, and finish them in Parian for paint; or in other cases the external walls are battened and lathed as hereinafter explained.

Prevention of Damp rising.—The ascent of damp is guarded against by the use of damp-proof courses, of different materials, laid across the whole width of the walls, a little above the general surface of the ground, and under all timbers, wall plates, etc., which are liable to be affected by damp. The following kinds of damp-courses are employed in different parts of the country:—

1. *Blue brick damp-courses*; which consist of blue bricks, with open cross vertical joints, laid in cement, and with the two next courses of brick, above them, built in cement mortar. This is a most effectual method, besides being inexpensive, and raising the building at the same time—assuming that there can be no objection on the score of appearance.

2. *Slate and cement* damp-courses are made of two thicknesses or courses of good non-absorbent slates, bedded and jointed in cement, and overlapping each other at the joints.

3. *Asphalte* damp-courses of Val-de-travers, Seysell, or Limmer asphalte, are very effectual, though a slightly more expensive remedy; still they have the advantage of being hidden in the joint, whereas the blue bricks would be apparent and out of character. The asphalte should be laid on hot, and by experienced workmen.

4. *Anderson's*, *McNeill's*, and *Engert & Rolfe's* patent fibrous asphalte felts are another effectual remedy, and particularly convenient; because, as sold, they are ready to be laid by the ordinary workmen, being made in lengths and to the widths of ordinary walls. They are either laid in single courses, lapped at the joints, or double—*i.e.*, in two thicknesses.

5. *Cement and sand*, gauged strongly (as one of cement and one of sand) is sometimes used as a damp-course; and it is effectual, but requires time to set, before any heavy work can be built on it.

6. A composition of *tar*, *sand*, *and pitch* is a common and successful remedy; though it requires experience in the boiling, as it will only set properly when laid on hot immediately after it has reached a certain state after boiling.

7. *Lead* is sometimes—though seldom nowadays—used as a damp-course. It is expensive, because it must be stout; besides which it has the disadvantage of being affected and eaten away by cement or lime; and it will not carry very heavy weights.

8. *Hollow vitrified brick blocks*, to allow the circulation of such a non-conductor as air, are also another effectual remedy, and frequently used. They are laid on in two courses, breaking joint.

9. Callender's bituminous damp-proof sheeting is very effectual, as well as reasonable in price, and it can be applied in continuous lengths.

Prevention of Damp descending.—The descent of damp, in special cases, such as parapet walls and chimneys, is stopped by similar methods to its ascent, as explained above. The common method, however—which only checks, but does not prevent the descent of damp, in ordinary walls and other places where it penetrates or descends—is to throw it off by weatherings and projections. All *string-courses*, sills, copings, and projections should be weathered or splayed, and the underside "check-throated," so that the wet runs down, and being checked by the throat on the projection (as at × in fig. 193), drops off.

Copings of stone or blue or red bricks are also used at the top of walls for this purpose, and may be either weathered and throated, as fig. 193; saddle-back and throated, as fig. 194; rounded and throated, fig. 195; or bull-nosed or half-rounded, fig. 196. All these are effectual except the last; this does more harm than good, as, without the throat, all the wet is collected and literally poured down the face of the wall.

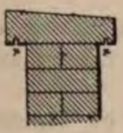


Fig 193

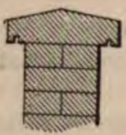


Fig 194

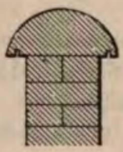


Fig 195.

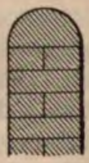


Fig 196

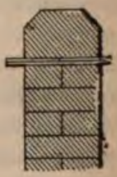


Fig. 197.

A *tile creasing*, as shown in fig. 197, is often also employed as a coping and projection to walls, and consists of two courses of tiles breaking joint, and built in cement, projecting from the wall line.

CHAPTER V.

BUILDING STONES AND STONE WALLING.

Stone as a Building Material—Sandstones—Limestones—Stone Walling—Limestone Facings—Sandstone Facings.

Stone as a Building Material.—It is only proposed, in this chapter, to draw attention to some of the chief points requiring attention with regard to building stones generally, after which a short account will be given of the nature and characteristics of the chief building stones in general, as against local use. Granite and other building materials, not mentioned elsewhere, will be found treated of in Chapter XXIII.

It will be patent to the student that, whereas hard-and-fast rules can be laid down for the guidance of bricklayers, to enable them to make good, solid, well-bonded work with a material of regular and standard size, no such rules can be made for the use of a material, such as stone, which is of no certain fixed size, and is subject to the varying influence of innumerable matters of both great and small importance. Therefore a great deal must necessarily be left to the judgment of the mason, who should thoroughly understand the principles, which he must endeavour, in more or less degree, to carry out, as far as possible, according to circumstances. He should never, under any circumstances, allow one joint to be exactly over another; but he can make the joint, in any position, over another solid stone, whether it be half or three-quarter bond. All he has to do—subject to judgment and discretion—is to break the joints; and, in addition to this, he must take care that every stone, excepting projections and weatherings, is laid on its *natural bed—i.e.*, on the bed on which it lay when in the quarry, before it was taken from the solid mass. This bed—except in very close, hard, uniform, and even-grained stones—can easily be distinguished, as all formation and stratification, shells, changes of colour, and nature in the stone, grit or other, are practically laid horizontally on the stone. Therefore such marks, indications, and peculiarities are generally found in lines approximately parallel with the naturai or quarry-bed of the stone.

On the other hand, all projections, weatherings, and especially copings, should be *joint-bedded*; that is, the natural or quarry-bed must be placed vertically and at right angles to the horizon or bed of the course, which is necessitated by the fact that wet and frost will penetrate the bed of a stone, and lift it up and sometimes off altogether. Therefore it is best to tie the beds in, as it were, together at the joints by neighbouring stones, so that they cannot get away.

The mason should also take great care that the surfaces of all beds and joints are at true right angles, with the face of the stone or the direction of the superincumbent pressure of the weight above, so that the pressure on the stones is equally distributed over the whole area of the stone—unevenness tending to cause the angles to split off the stone, from the influence of gravity, making it take its proper bed and bearing under the pressure (as fig. 198), or sometimes the stone cracks (as in fig. 199).

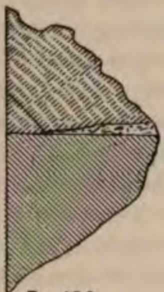


Fig. 198.

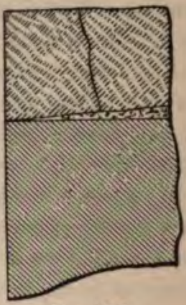


Fig 199.

Bonders and their uses will be dealt with later on, in connection with the subject of walling.

There are two classes of building stone in general use, called, from their respective composition, sandstones and limestones. *Sandstone* is composed of pure, clean sand, cemented together by carbonate of lime or of magnesia and other binding substances, while *limestone* is little more than pure carbonate of lime. The varieties of stone are of numerous colours, including red, blue, brown, white, and yellow, and their innumerable shades. The grain varies from fine to coarse, with beds which are oftentimes difficult to distinguish, some being close and some open, though their strength may be the same.

Sandstones.—Sandstones are used for paving, general building purposes, carving, or for heavy engineering works, on account of their great power to resist compression, some of the best qualities being capable of resisting a pressure of between 600 and 700 tons per square foot before they *crack* even, and more before being *crushed* completely. They are hard, though free-working, and durable; they absorb from 8 to 10 per cent. of water; and their weight is from 120 to 170 lbs. per cubic foot.

A good sandstone should be of an even grain, and crystalline in texture. When chipped into clear water, and stirred about, it should not make the water muddy; and it should absorb no more than 10 per cent. of water when poured on to it, while for work requiring strength it should be capable of taking, at the very least, 350 tons per square foot in compression before fracture takes place.

The best and most well-known sandstones are as follows:—

Craigleith stone is the most durable in Great Britain, found near Edinburgh. It contains 98 per cent. of pure silica, with 1 per cent. of carbonate of lime. It is of a greyish colour, very hard, durable, and strong—some beds being three times as strong as Aberdeen granite—and of such a fine grain that it may hardly be called a grit. It takes a very fine arris, and never wears smooth. Its principal use is for steps, paving, etc., and heavy engineering works requiring great strength.

The *Derbyshire* sand or gritstones are a very useful and good stone, weathering well, carrying a fine arris and nice even-coloured face, especially the Burntwood and other fine Darleydale qualities, which have been proved to withstand a smoky atmosphere where other stones have decayed; and the coarser qualities, found near Matlock Bridge, have great powers of resistance to crushing, rendering them most suitable for pad-stones, engine-beds, and column-bases. Stone blocks of such a size as 8 feet square and 3 feet deep are often procured out of the best quarries.

Forest of Dean stone is found in Gloucestershire, among the coal measures. It is both soft and hard, according to bed, the best yielding a hard stone, of a fine grit, which can be quarried in large blocks.

Mansfield stone is found in Nottinghamshire, and of two kinds, respectively red and white in colour. It is a close crystalline gritted stone, quarried in large blocks, has a nice uniform appearance, is easily worked, weathers well, and is suitable for dressings, pavings, stairs, and ornamental work generally. Mansfield stone is called a *dolomite*, and contains almost equal quantities of the carbonates of magnesia and lime.

The *Yorkshire* stones are of many varieties, including Bramley Fall, Scotgate Ash, Parkspring, Robin Hood, Elland Edge, Howley Park, and Spinkwell; most of which are good hard stones, suitable for paving, dressings, pad-stones, and engineering work. They work and weather well, stand considerable wear, and are close and even in the grain, brown or blue in colour, and of numerous shades.

The Yorkshire quarries are worked by open workings, or by shafts, in a similar manner as coal, some of the beds being sandstones of the lower coal measures. The depth of stone varies from a few feet to over two hundred feet below the surface. The quarries produce "blocks" and "flagstones"—the latter being converted into stills for chemical works, flagging for streets, kitchens, passages, etc.; while the thinner lifts are used as roofing "slabs," the small pieces of the flags being dressed into wall stones.

The *block stone* produces the thicker kinds of flagstone, and is sawn into slabs for use in staircases, chimneypieces, dressings, and monumental work; the waste or smaller pieces being converted into "setts" and "paviors" for streets.

Of the brown and blue varieties found, it must be understood that the latter is by far the better stone where strength is required, it being capable of taking a weight of 668 tons before cracking, and 728 tons before being crushed, whereas brown will only bear the pressure of 484 and 514 tons respectively, these results being obtained on 6-inch cubes.

Runcorn is a good, useful, strong, durable, red building stone, found near Liverpool, being free-working, and of nice open grit.

Cefn, a yellow grit stone, of fine grain, is found in Wales, and used for most building purposes.

Hollington is another good weathering sandstone, either red or white in colour, found in Staffordshire, and very often used for general building purposes.

Limestones.—Limestones, as a whole, are inferior as building material to sandstones generally, though Portland may be considered as excepted from that category. They consist of almost pure carbonate of lime, and are, of course, affected by the sulphurous and smoky atmosphere of large manufacturing towns, which gradually eats away the stone. Compared with sandstones, as a building stone, they are less durable; they weigh from 116 to 150 lbs. per foot cube, withstand a pressure of about 250 tons per square foot, and are much more easily worked, especially when freshly quarried and *green* with *quarry sap*.

The best of the limestones are dense and uniform, both in structure and composition, with a fine even grain, and crystalline texture; and moreover, they will weather well, and, especially in some atmospheres, are the most economical stone, being preferred for their uniform colour and facility of working. They are often coated with other substances, to preserve them, as will hereinafter be explained.

A good limestone should have most of the qualities enumerated above, absorb no more than 17 per cent. of water, and be free from any earthy or dull appearance. There are several classes of limestone, including the *Compact*, the *Granular*, the *Shelly*, and the *Magnesian*. The first of these is chiefly used for road material, pavings, etc.; wherefore it is unnecessary to refer to it, not being a building material.

Granular limestones, as the name implies, consist of grains of carbonate of lime cemented together by the same substance; and they belong to the Oolite formation, those with large grains being called *Pisolites* or *Pea stones*, and those with small grains *Roe stones*, because they resemble the roe of a fish in appearance. They are of a brown or yellow colour, and, from their nature, rather absorbent, and liable to the attack of acid in a town atmosphere; though some of them are less so than others, and will weather well in ordinary positions. Among their number must be included several very good and commonly used building stones, viz.:—

Bath Stone is perhaps the best-known building stone in the country, being a free-working oolite, containing 95 per cent. of pure carbonate of lime, and of various kinds—including Box Ground, Coombedown, Monks Park, Corngrit, Corsham Down, Farleigh Down, Westwood Ground, and Winsley Ground—all similar in general appearance, and only to be correctly distinguished from one another by a skilled and practised eye. St. Aldhelm Box is the best weathering stone of the lot; and Corsham or Monks Park is the most suitable for external work, other than weatherings; while the other varieties are only fit for interior work, though they are good soft suitable stones for inside purposes.

The Bath Stone quarries are really stone mines, because they are worked partly underground, the depth of stone varying from 6 to 20 feet, running in fairly level beds, increasing in depth the lower they get. The quarrying is done by the use of pick and saw, without any explosive, a horizontal groove about 10 inches high and 5 feet deep being picked out next the ceiling of the mine, into which groove the quarryman puts a saw, working downwards to the bottom of the bed, nearly 4 feet down. Another cut is then made at a distance of 3 feet from the last, and directed towards it at the back, making the stone-block narrower at the back than in front. The block is then got by means of wedges inserted under the bed, at the bottom, and into the saw cuts at the side, and these being driven home, they burst the stone off at the back, and the block is brought out. The quarrymen then have a start into that bed or beds, the other stones being easily procured afterwards, and trimmed with axes and saws into the required sizes of blocks.

The colour of Bath Stone may be said to be light brown, creamy, or stone colour. It is of a nice, even nature, and good, when free from yellow or earthy beds, easily worked, and suitable, in one or other of its varieties, for most purposes—especially when coated with the *fluate* which the "Bath Stone Firms Limited" recommend as a means of hardening and preserving its face—so that, taking all things into consideration, it is a most useful building stone.

Portland, containing 95 per cent. of pure carbonate of lime, is, in very many ways, a splendid stone, of the Oolite formation, found in the island of Portland, in quarries with generally three different beds, in use for different purposes, as follows:—

The *roach* bed, the first good one found in the quarry, is a mass of fossils, thoroughly cemented together with pure carbonate of lime. The fossils are like a corkscrew in form, and only appear in this bed, which is of a light brown colour, very tough and strong, and of a very high resistance to the action alike of air and water; so that it is in great requisition for engineering works of all kinds, though not for ordinary building purposes, on account of the fossils and the holes in it.

The *whit* bed, of either a white or brown tint, comes next to the roach, and is a fine, open, well-cemented, hard, and crystalline stone, suitable for the best buildings, and capable of taking a good arris and smooth face, while it weathers excellently well. It is "roe"-like in appearance under a microscope, and hard to distinguish from the "base bed," an inferior quality found lower down in the strata.

Next to the whit bed comes the *bastard roach*; distinct from the true roach, which it resembles in appearance, though it never contains the "screw" fossil among its mass of fossils, and its cementing matter is so bad that it is altogether inferior; in fact, not fit to use at all for any purpose.

The *base bed*, coming next, is a similar stone to the whit bed, but not so good, being softer and not able to withstand the weather; though it is often substituted for the whit bed, from which it can hardly be distinguished.

Caen is a soft, creamy-coloured stone, used only for internal work, carving, etc., and is found in Normandy.

Chilmark, *Tisbury*, or *Wardour* stone is more of a sandy nature, found near Salisbury, and considered to be a good, durable, fair-working stone, which weathers well, and can, from certain beds, be adapted for internal staircases, not exposed to extraordinary wear, besides being suitable for general purposes.

Ketton is another good, useful stone of this formation, and one which shows the "roe-stone" grains very plainly. It is found near Stamford in three qualities, the hard, medium, and soft; the best of which is very durable, free-working, and suitable for all kinds of dressings and stairs.

Of the *Shelly* limestones, the only one of any note used for building purposes is the Hopton Wood (found in Derbyshire), which is a very hard stone, looking well on account of the fossils it contains. It is capable of taking a polish, and is suitable for steps, staircases, chimneypieces, and other ornamental work.

The *Magnesian* limestone formation supplies us with a few good stones, which are called Dolomites (as previously mentioned), the chief variety being *Bolsover* stone, found in Derbyshire, of a light yellow-brown colour, and of great durability. It is crystalline, and very even in texture, and was extensively used in the erection of the present Houses of Parliament.

Stone Walling.—In stone walls, the material should be bonded just the same, and for the same object, as in brick walls—*i.e.*, as regards breaking joint both vertically and horizontally; though this, for obvious reasons, cannot be done in rubble walls. Consequently such walls are weaker, and of necessity have to be thicker to be of the same strength as brick and other uniformly bonded walls. Moreover, rubble walls the stones from which they are built having neither square beds nor joints —require a greater quantity of mortar to bed each irregular-shaped piece of stone, and as a result, there is more and unequal settlement in them on the drying of the mortar. This is a defect which cannot but have prejudicial results when rubble walls are faced with brick or stone, set with square beds and joints, and, of course, less mortar.

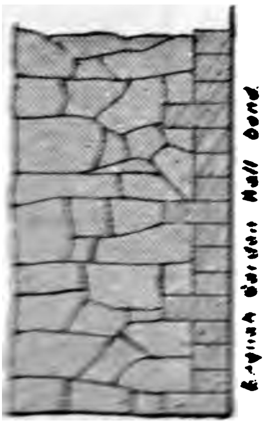


Fig 203

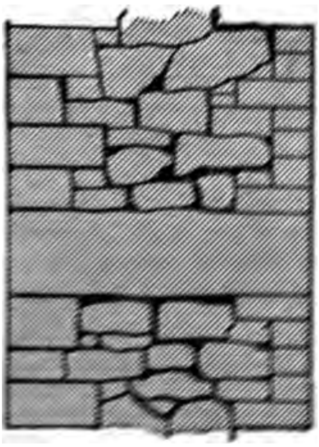


Fig 204

The facing or linings, whether of brick or stone, to rubble stone walls may be thoroughly bonded as in fig. 203, which is a section of a [illegible] lined rubble wall, but this has little advantage as regards their strength as a whole.

On an average not less than three [illegible] superficial yard of stone facing in rubble walls [illegible] no uniform mass as it should be. Another disadvantage is that "through" bonders of porous stone conduct damp and moisture into a building.

The courses of stone-facing, in addition to special bonders, as previously explained, should not be all of one depth on the bed, where it is possible to have them of depths similar to brickwork—*i.e.*, with two or three courses of about 4½ inches or more on bed to one of about 9 or 12 inches, and so on, in like principle and proportion.

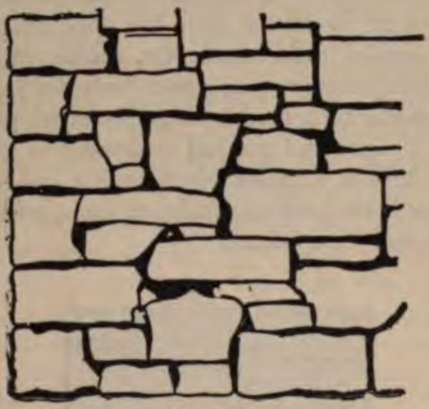
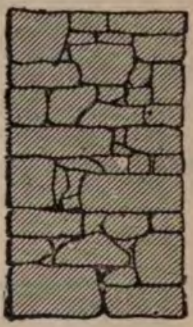


Fig 202



Section
Fig 203

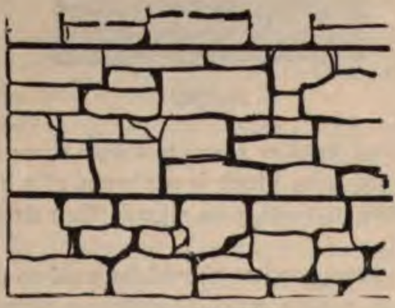
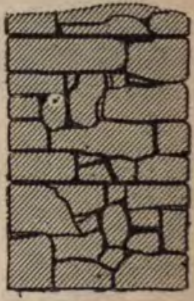


Fig 204



Section
Fig 205

The different kinds of stone walling or stone facing are—*Random rubble*, illustrated by figs. 202 and 203, in elevation and section; from which it will be seen that it is stronger and more solid when not faced, though weak under any circumstances.

Random rubble built up to courses, as in figs. 204 and 205, is little better than the last, though levelled up at every foot or two of height.

Squared or snecked uncoursed rubble, as figs. 206 and 207, is far superior in every way to either of the preceding, being built of stones which have had their beds and joints squared or snecked, and consequently require less mortar, with less moisture to dry up and cause settlements. In snecked or squared rubble, to ensure the best work, the jumpers, or large blockers rising above their neighbours, should not be more than 10 inches high, and proportionate to the size of the adjoining courses.

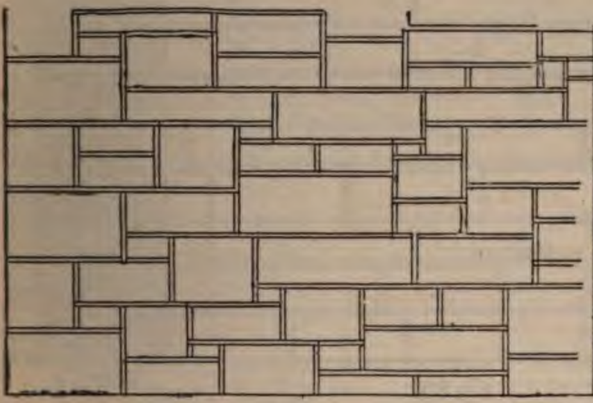
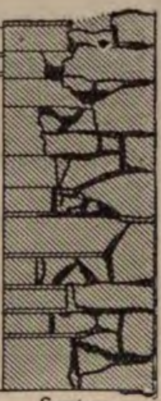


Fig 206



Section
Fig 207.

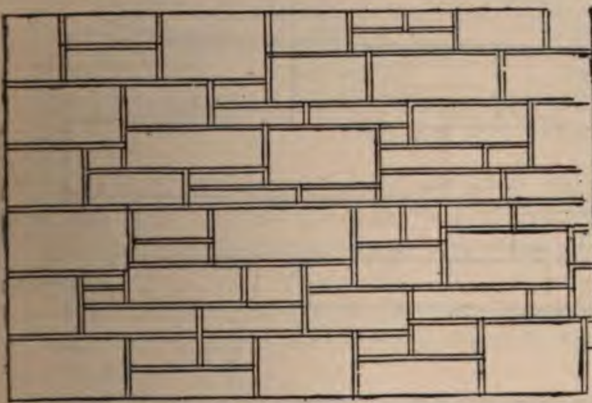
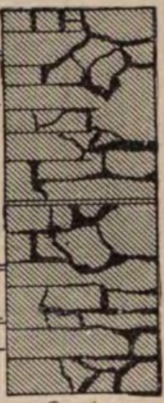


Fig 208



Section
Fig 209

Squared or snecked rubble built up to courses is illustrated by figs. 208 and 209, where it will be seen that this kind, like "rubble built up to courses," though of stones irregular in size, can be built up and levelled as a horizontal course every 12 to 18 inches instead of every course, or not at all.

Squared or snecked coursed rubble, which it will be seen demands that each rise of stone shall form a horizontal course of its own, is illustrated by fig. 210.

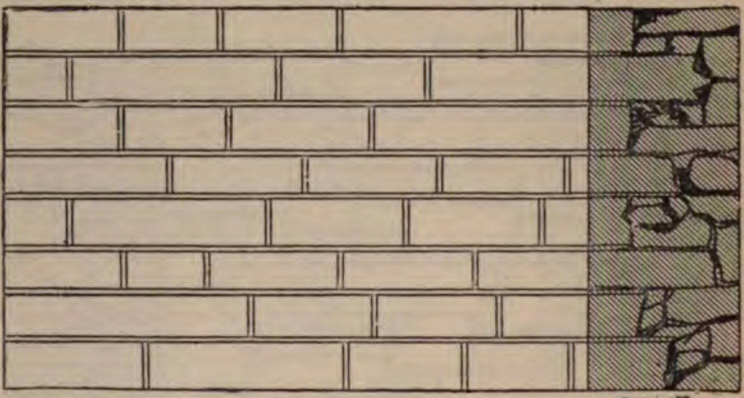


Fig 210

Ashlar, as shown in fig. 211, is the finest of all facing, being built on a regular system, and with finely chiselled, perfectly horizontal beds and vertical joints, so that, when set in the work, the joints show no more

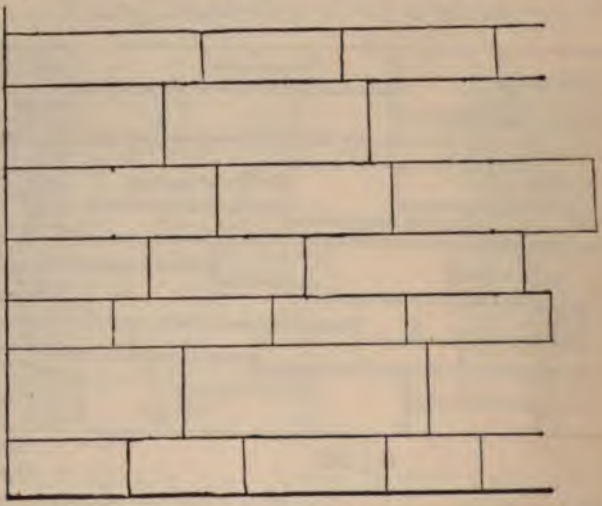


Fig 211

than ⅛th of an inch; and good ashlar is never supposed to rise more than 9 or 10 inches in a course; and, in limestone or soft stones, each stone hould be no more in length than three times its height, or in depth 1½ times to twice its height—*i.e.*, on the bed. Sandstone will take about half as much again—*i.e.*, 4½ times its height for its length, and from 2 to 3 times for its depth.

Block in course, which really is large ashlar, or that which exceeds the limit in height, rising from 10 to 16 inches each course, is illustrated by fig. 212.

Limestone Facings (as shown in figs. 206, 208, 210, 211, and 212) may have the faces of the stones treated in various ways, as follows:—

1. *Axed*, by which is meant that the face is gone over with a mason's axe, leaving rough, irregular, coarse, vertical ribs or marks.

2. *Chopped*, which is a superior finish to the last-named, the ribs being much closer and finer.

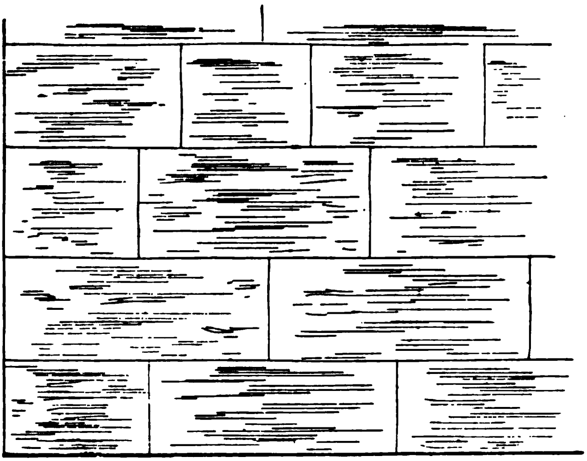


Fig. 212

3. *Rock-faced*, in which the beds and joints are squared, as in the others, but, from a line all round, the face is knocked off slanting from the four sides towards the centre to look rough and with a rock-like appearance.

4. *Dragged* is the finish made on plain limestone ashlar by means of a tool, toothed like a saw, which is drawn backwards and forwards across its face.

Combed is the term applied to the finishing off of moulding in limestones.

Sandstone Facings of a hard nature may be treated as follows:—

1. *Scappled, or scabbled, punched, or boasted*, which are terms applied to the rough labour employed on beds, and the rough squaring up of hard stones for engine beds, etc.

2. *Chiselled* work has the face worked over either on the straight or

skew with a chisel, the marks or "bats" often being as close as 8 to the inch.

3. *Tooling* is done with a broad "chisel," the strokes being parallel to the joints, and from 3 to 5 to the inch. (This is called "droved" work in Scotland.)

4. *Hammer-dressed* is the term applied to work done with a hammer with a chisel point, by which the face is roughly levelled, leaving indents where the chisel has been. It is also called "broached" work.

5. *Scutched* work is similar to the last, but more finely executed.

6. *Drafted and broached* is the term used for the work done to quoins, a draft or margin being chiselled or tooled round the face of the stone, and the panel enclosed thereby is hammered or broached down to give it a rough appearance.

7. *Drafted and diamond-picked or hammered* work is similar to the last, but the panel from its roughly chiselled face is "picked up" by a number of small points in the form of a hammer, which is like "frosted" work on tombstones.

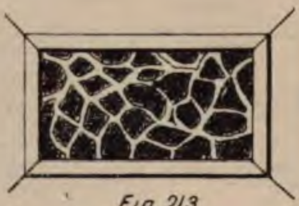


Fig. 213

8. *Vermiculated* work is that used in large base stones; the face being first chiselled, and afterwards large deep holes are picked out, no mark of the tool being left, as in fig. 213.

9. *Rubbed, cleansed, or polished* work, as the name implies, has its face smoothly rubbed, after being chiselled down level or to the required shape.

10. *Pointed* work has its face first chiselled, after which the "chisel hammer" is driven along its face longitudinally with a long sweep whereas "scutching" is done with short strokes.

Polled work is the term applied to hard stones such as granite and whinstones, a large square short hammer being used to split and square up the stones.

Some stones, and especially limestones, in some atmospheres will never weather nor last without being coated over with some material There are numerous preparations which are recommended in order to prevent this decay, those containing a silicate of an alkaline nature being the most efficacious; though such simple things as paint, soft soap, milk, or paraffin are frequently used, in a smaller degree, with a fair amount of success. The best remedies now in use may be said to be: (1) Szerelmy's, said to be a bituminous solution of a silicate, which is applied in two or three coats with a brush; and (2) Carbolinium Avenarius, a preparation made by Peters of Derby, which is said to preserve both stone and wood with success. The Houses of Parliament were coated with Szerelmy's solution.

The Bath stones class should be coated with the "fluate" recommended by the firms who supply the stone.

CHAPTER VI.

STONE DRESSINGS, JOINTS, AND STAIRS.

Plinths—Sills, Heads, and Jambs—Mullions and Transoms—Hoods or Labels—Strings and Cornices—Parapets and Balustrades—Quoins—Copings—Joints—Steps—Hand-railing.

STONE dressings are used for the ornamental finishings of a building, being worked to various details out of free-working stones; and they may be said to include the following different members (*vide* figs. 214, etc.):—

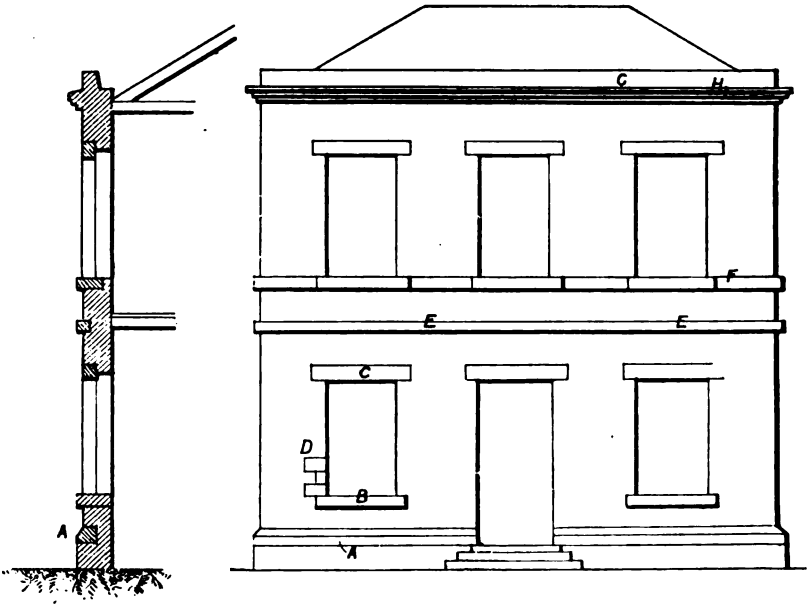


Fig. 214.

Plinths, the horizontal course A, on fig. 214, which can be eithe chamfered, as shown in fig. 215, or moulded, as fig. 216, a "set-off generally taking place at this level.

Sills, as at B, on fig. 214, are the finish to the bottom of openings for windows, in contrast to steps for doors, their object being to throw off the water which naturally would collect on a flat surface. They can be plain, as shown in elevation and section in figs. 217 and 218, or moulded, as figs. 219 and 220. They should project not less than 2 inches beyond the wall line, and be *throated* (as at X) on the underside, to make the water drop down.

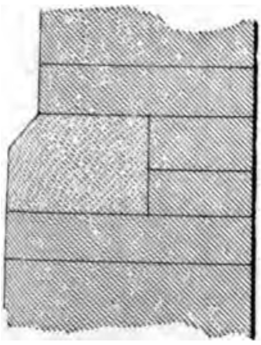


Fig 215.

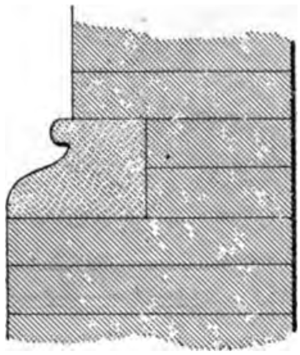
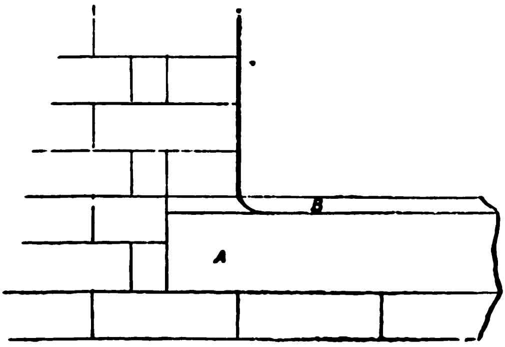
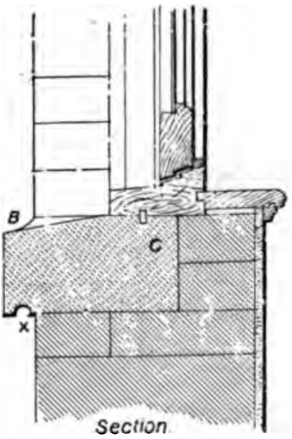


Fig. 216.

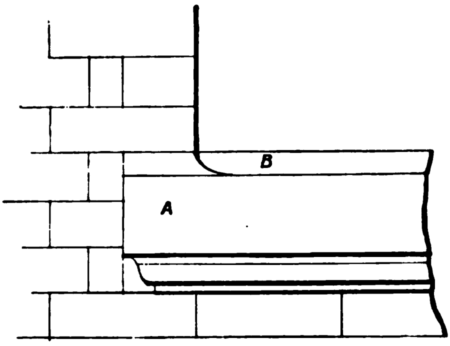


Elevation.
Fig 217.



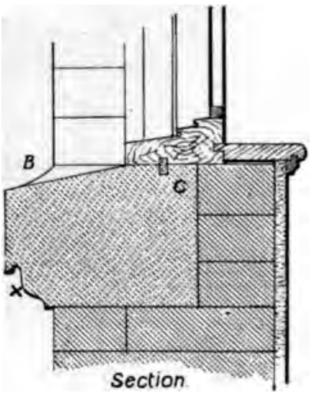
Section
Fig. 218

Sills are built into the jambs from 3 to 6 inches; the portion on which the first jamb, brick, or stone is bedded truly level as a bed to start from being called a *stooling*, or *seat* (as A on figs. 217 and 219); the weathering at B being stopped and worked up to it, and the moulding mitred and returned and stopped, as on figs. 219 and 220. It is also necessary that sills be grooved, to receive the lower half of a metal tongue, of which the upper half is also let into the underside of the wood sill, to stop any draught



Elevation.

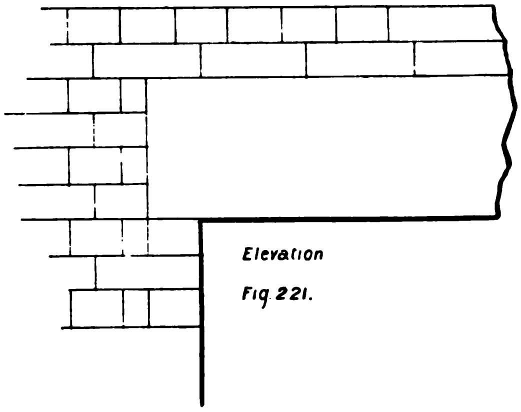
Fig. 219



Section

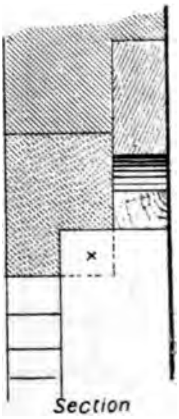
Fig. 220

from getting between the beds, as at C, figs. 218 and 220; and stone sills are only bedded in mortar under the jambs and mullions to prevent cracking on the building taking its settlement; they are "pointed up" afterwards.



Elevation

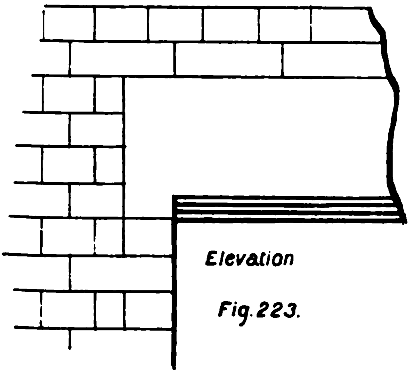
Fig. 221.



Section

Fig 222.

Heads, as C on fig. 214, support the wall above the opening, and may be either plain and square, as figs. 221 and 222, moulded, as figs. 223 and 224, the moulding being stopped at the jamb, or stop-chamfered, as figs. 225 and 226—the heads in the preceding cases being revealed for the head of the frame, as marked X in figs. 222 and 224, whereas fig. 226 is plain at the back.



Elevation

Fig. 223.

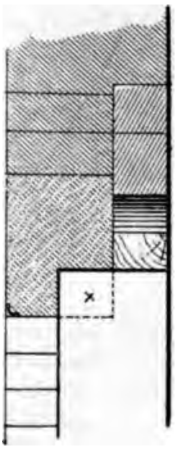
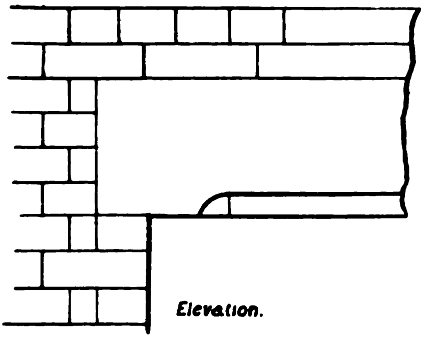
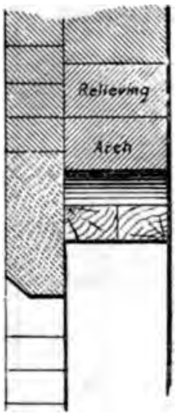


Fig. 224



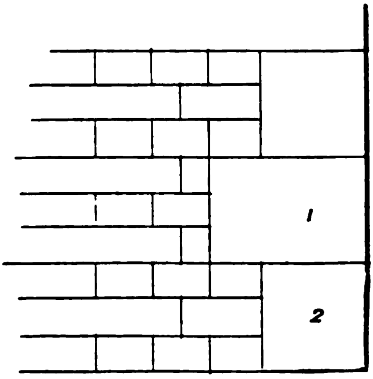
Elevation.

Fig. 225.



Section

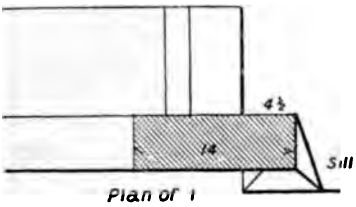
Fig 226



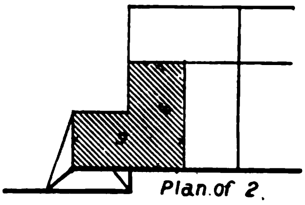
Elevation.

Fig. 227.

Jambs, D on fig. 214, are the finishings to the angles of openings, where stone is used instead of bricks, each stone being made of such dimensions as will work in with the bricks without cutting. They may be either moulded plain or chamfered—as the heads; and those which are the wider on the face (as at 1, figs. 227 and 228) are called "out-bands," and the narrower ones (as at 2, figs. 227 and 229) are called "in-bands," because they go inwards beyond the reveal, and are checked or revealed out, for the frame, as shown on plans (figs. 228 and 229). They can be moulded or chamfered on the edge.



Plan of 1
Fig. 228.



Plan of 2.
Fig. 229

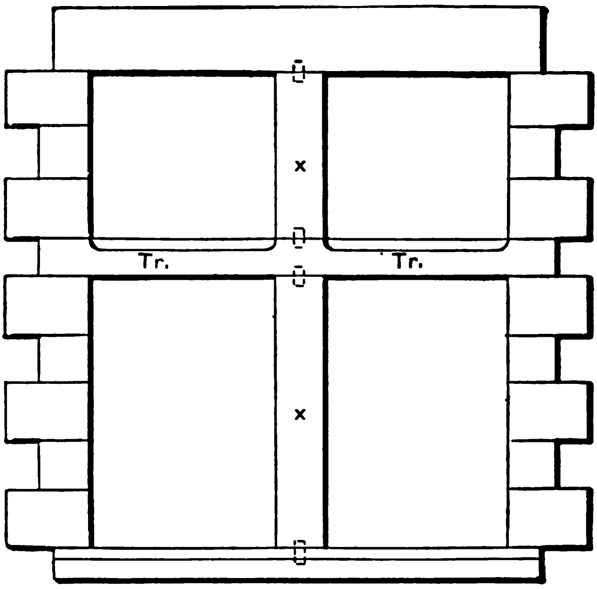


Fig 230

Mullions are the uprights between two lights of a window, as X on fig. 230; and they may be either square on plan, as at A, revealed, as B, or moulded and panelled, as C (*vide* fig. 231).

Transoms divide the window-lights horizontally, as Tr on fig. 230, being weathered on the top bed and throated underneath, as fig. 232, and with stoolings, like sills, to give the perpendicular members a level bed to start from.

Hoods or *Labels* are mouldings, either worked on the solid head or of

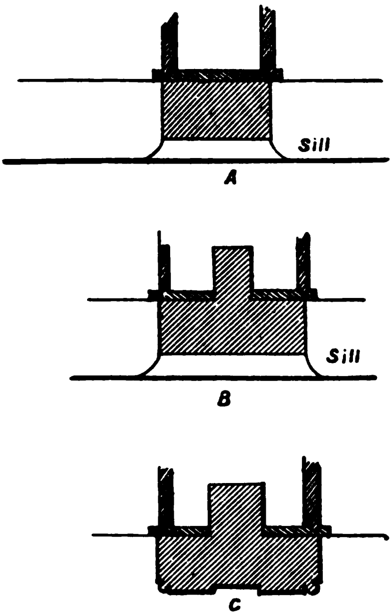


Fig 231.

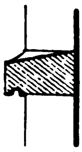


Fig.232.

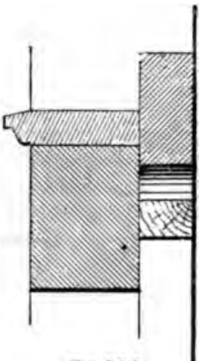


Fig 233.

thin stone moulded on the edge, as fig. 233. They are placed over window and door-heads to give them a greater effect.

Strings are longitudinal horizontal courses, either plain or moulded,

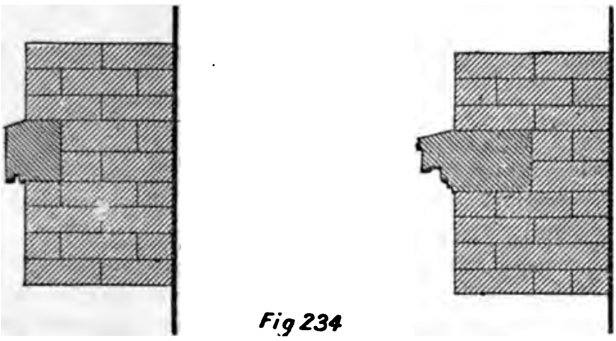


Fig 234

running round a building and dividing it in height, as it were, into floors, as E, fig. 214; or simply a continuation of the sills between openings, as F. Fig. 234 gives sections of a plain weathered and throated and a moulded string course.

Cornices are the longitudinal mouldings which go along the top of the building, as H, fig. 214, being weathered on top and more or less moulded, as fig. 235. When they are quite plain, and only used for supporting the gutter of the roof, they are called *eaves courses.*

Blocking courses are the top members or crown of a cornice, as G, fig. 214, and X, fig. 235; whereas a *frieze* is the plain part below, and the small moulding below that is called the *necking.*

Parapets are thin walls, at the eaves of a roof, behind which the gutters are formed; and they take the place of the blocking courses, where greater height is required.

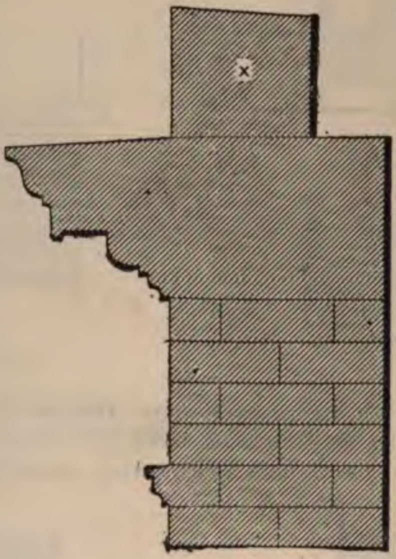


Fig 235

Balustrades are used for a similar purpose; but they are of a lighter and more ornamental appearance, consisting of turned balusters enclosed within a base and cornice, as fig. 236.

Quoins are the stones used at the angles of the building, being made to range with the brickwork. They vary in size from 18 inches to 14 inches on the one face by from 10 to 13 inches high, and the return face would be 9 or 14 inches wide, the stones being of the same size, but placed alternately to show a long face in front and a short one on the return, and *vice versâ,* as figs. 237 and 238. Of course, in stonework they are larger in size, according to the character of the building.

Plain-cut quoins are those shown in figs. 237 and 238.

Drafted and hammer-dressed quoins are of the same sizes, but with the faces worked, as previously explained in Chapter V.

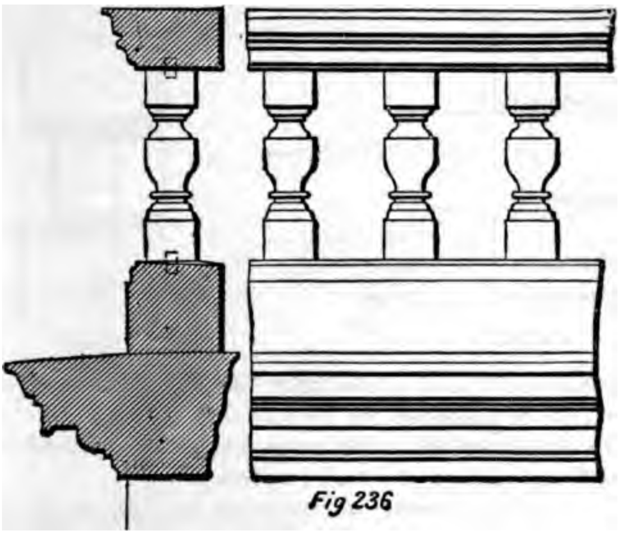
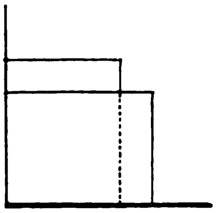
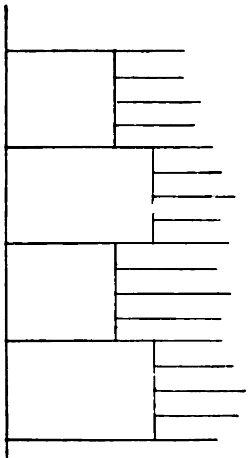


Fig 236

Drafted and diamond-picked, rock-faced, vermiculated, tooled, or *chiselled quoins* are similar in size and application, but worked in a different manner as the name implies (*vide* also Chapter V.).



Plan.
Fig. 237.



Elevation.
Fig. 238.

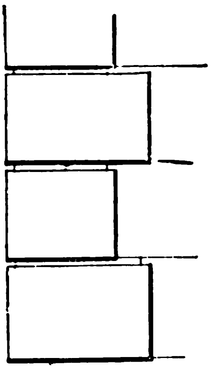


Fig. 239

Rusticated quoins are as fig. 239, having a rebate sunk out of every alternate stone at the bed.

A chamfer on each joint or bed, forming a V joint between the two beds, is often substituted for the plain rebate, as fig. 240; or again, the joint may be moulded, as fig. 241.

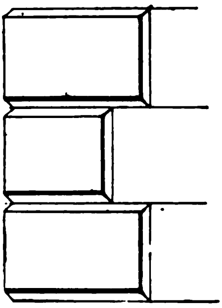


Fig. 240.

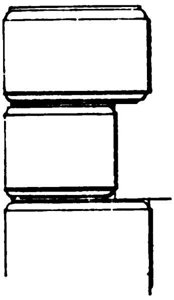


Fig. 241.

Birdsmouth and squint quoins refer to the irregular internal and external angles, as explained for bricks.

Scuntion quoins are the rough squared angle quoins used in rubble walling at the plumbings of internal openings.

Copings to walls, otherwise called *water tablings*, are explained in Chapter IV. (figs. 193, 194, 195, 196, and 197) under Brickwork: the same remarks and illustrations applying to stone copings, which, it must be noticed, are much extensively used; and especially up the sloping tops of gable-walls, as X, fig. 242.

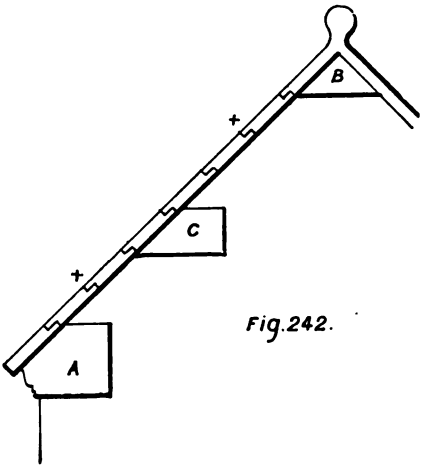


Fig. 242.

The bottom stone, A, with the coping worked on it as shown, is called a *springer*; that at the top, B, the *apex*, being similar to a ridge; and intermediate stones, C, whereof the object is to give the coping a firmer hold on the wall, are called *kneelers* or *knee-stones*. Fig. 243 is a section of the coping described as moulded, throated, and *feather-edged*, because it is weathered from a thick edge to a thinner one.

It is almost needless to remark that most of the above dressings are worked with labours similar to those explained in Chapter V.; so that a special name given to a particular dressing is intended to convey to the student the manner of the labour that it has had upon it, as previously explained with regard to quoins.

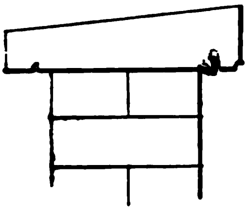


Fig 243.

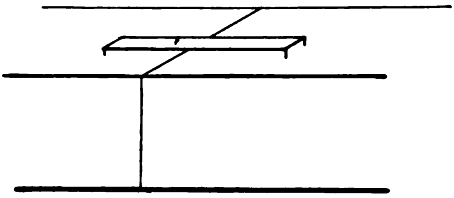


Fig 244

Good masonry often requires that the joints be secured together by special means, so that the various members may be united into one mass, in length as well as in height. Longitudinally they are bound together by means of *cramps*, which are strips of galvanised iron or copper, turned down at each end into each of two adjoining stones and run in with molten lead, or "leaded in," as figs. 244 and 245.

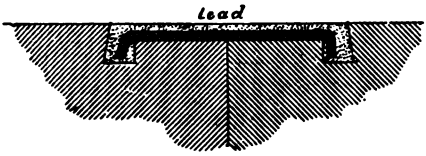
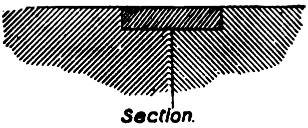
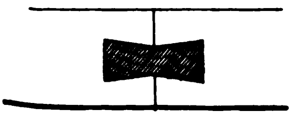


Fig 245



Section.
Fig. 246.



Plan.

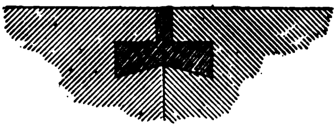


Fig 247.

Lead dovetails or plugs consist of a wedge-shaped mortise cut into each stone at this joint, as fig. 246, and run in with lead, which binds the two stones together. Sometimes this dovetail is mortised out below the bed of the stones at the joints, as fig. 247, the lead being poured in through the hole from the top or bed-joint.

Rebated joints are suitable for copings to gables and similar work, a rebate being sunk out of each stone alternately, as fig. 248, one stone lapping, as it were, into the rebate of the other.

The stones are secured vertically by means of *dowels*, either of pebbles, slate, or copper, about 1 inch square, and of different lengths, according to circumstances; one half or part being let into the top bed of the bottom stone, the other half going into a similar mortise on the bottom bed of the upper stone, as fig. 249. They are run in with cement to render them firm and to fix the dowels securely in the mortises. This joint is very suitable, and much used for securing mullions to sills, heads, and transoms at the stoolings.

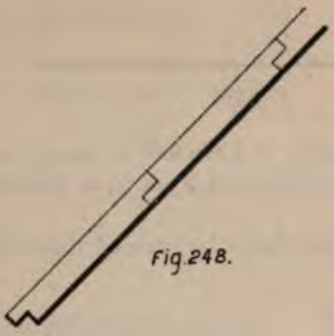


Fig. 248.

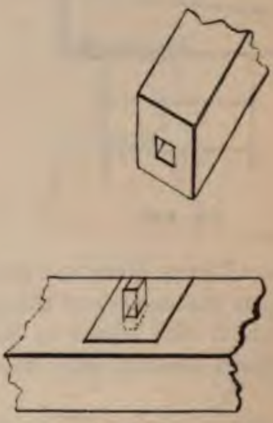


Fig 249

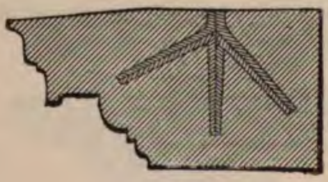
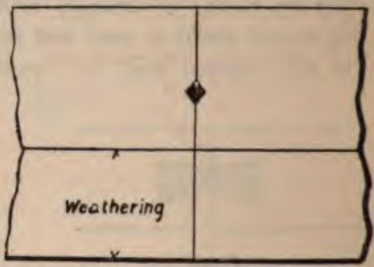


Fig 250



Joggle joints are used to connect stones in different positions, this form of joint being suitable for ashlar, as well as for cornices, strings, landings, etc. The simplest form of it is to cut a V groove roughly on the joints of adjoining stones, as fig. 250, and, when they are bedded up to each other, to run into the hole liquid cement, which sets hard, and connects the stones together. *Landings* are *joggle-jointed*, as in fig. 251, the tongue, as it may be called, on the one stone being let into a groove of similar section on the other.

Tabled joints are little used, but they are formed by letting a wide projection of one stone into a sinking in another.

Cornices and other large projections often have their joints *saddled*, which is done to throw the water off the joints, being carried out by leaving a projection or stop on the weathering at the joint at each end of each stone, as fig. 252.

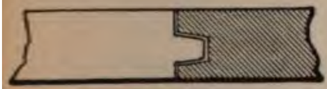


Fig.251

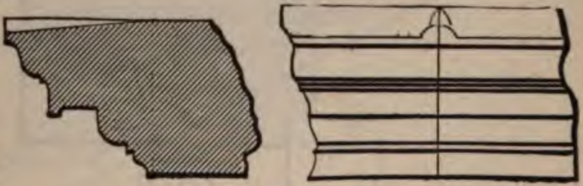


Fig 252

Dressings for *stone stairs* have the same names and terms (as far as they go) applied to them, as will be explained under "wooden stairs," Chapter XIX., to which the student is referred. But stone stairs, unlike wood stairs, are of simple construction, though they may be of the same various kinds.

Stone steps consist of solid blocks of stone, of various sections—square, as fig. 253, and spandril, as fig. 254—each being plain or moulded, according to taste. They are supported by being built into the walls from 4½ to 9 inches, according to the width of the stair and the projection of the steps, or the distance to which they hang out. Some kinds, however, are built with both ends into the walls, as in straight stairs similar to fig. 798 (Chapter XIX.).

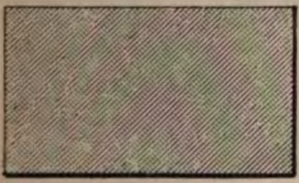


Fig.253

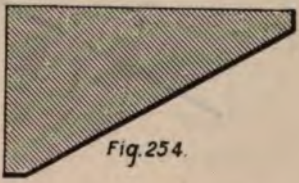


Fig.254.

Dog-legged stairs, as fig. 804 (Chapter XIX.), whether with or without winders, and *open*, or *geometrical* stairs, as explained by figs. 812, 815 (Chapter XIX.), are, of course, essentially hanging stairs, tailed into the enclosing staircase walls from 4½ to 12 inches, as required, the landings also being treated in the same manner. Each step is supposed to assist in supporting those above it, and for that purpose, and for better workmanship, they are jointed, as figs. 255, 256, and 257; the latter bein section of a moulded step, of which the end view, with the mould returned, is shown on fig. 258.

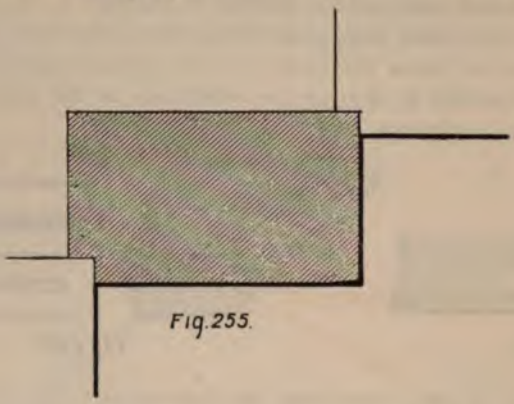


Fig. 255.

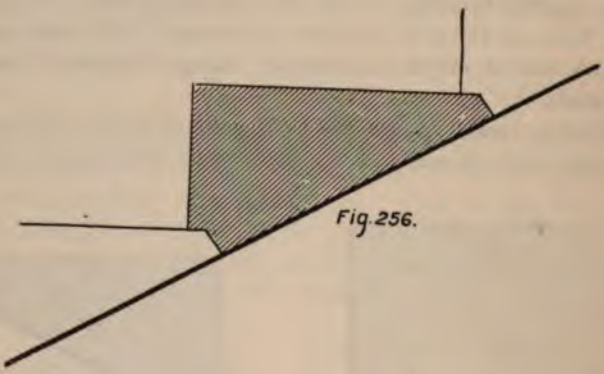


Fig. 256.

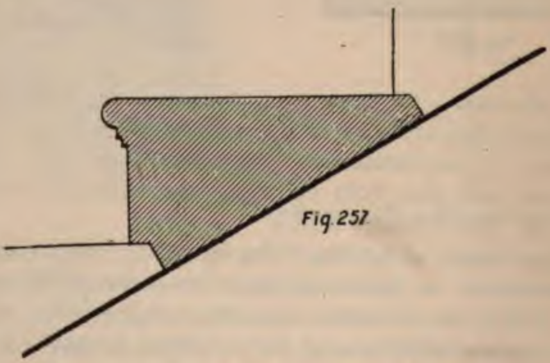


Fig. 257.

The soffits are generally left plain, with a rubbed face.

Circular stairs, or turret steps, are built up of steps of a form illustra by fig. 259, the wide ends being built into the wall and the rounded ends laid one upon the other, forming a sort of newel in the centre, from which all the risers radiate, appearing on plan as fig. 260.

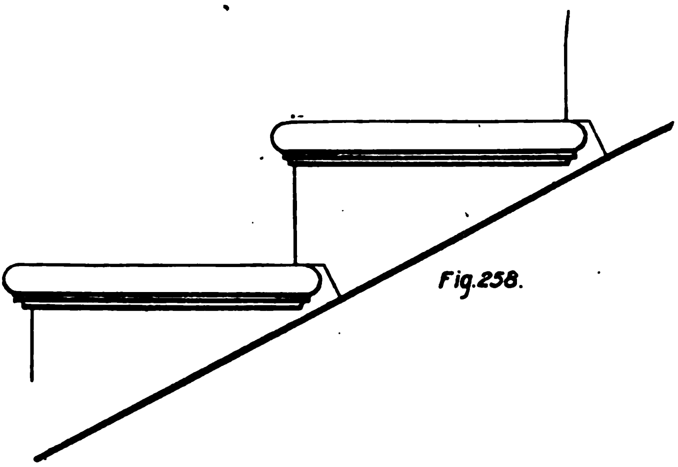


Fig. 258.

The handrailing of stone stairs is generally supported by wrought-iron bar balusters, about 1 inch square, mortised and leaded into the tread of each step, though sometimes they are secured by burning liquid sulphur, which sets very hard on cooling.

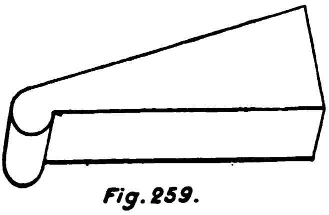


Fig. 259.

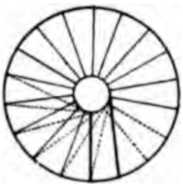


Fig. 260.

The newels may be of wrought or cast-iron, according to the amount and class of ornament required, mortised and leaded into the steps (like the balusters). The whole may be filled in with scroll-work or other ornament, to make it showy and light, according to taste. The tops of the balusters and handrail are connected by a thin wrought-iron core, which is sunk into the underside of the handrail, and secured by screws, making the staircase and its requisite accessories one connected mass.

CHAPTER VII.

WOOD FOR BUILDING PURPOSES.

Carpentry and Joinery—Wood in the Tree—Good and Bad Timber—Seasoning of Timber—Preservation of Timber—Deal or Fir—Elm—Oak—Teak—Mahogany—Walnut—Beech—Ash—Sycamore—Birch.

Carpentry and Joinery.—In one or other of its many and varied kinds and forms wood is the material which, in the building trade, almost exclusively, as it were, belongs to the carpenter and joiner, being the chief material to which their labours are devoted. It will, therefore, be advisable, before entering upon a detailed description of the various kinds, to explain the difference between the two trades above named; for, although practically allied, each uses either a different kind of wood, or different tools to work it, or deals with it in a different method or form.

Carpentry, generally speaking, is the term applied to the woodwork in the carcase of a building, including centres, floors, roofs, partitions, and other rough framings, which are required for construction, and are intended, figuratively speaking, to be the foundation for the other trades, including that of the joiner.

Carpentry, in other words, is the art of putting together or framing the rough materials which form the carcase of a building; whereas joinery deals with the completion of the building as regards interior finishing, convenience, utility, and adornment.

In the former, the principal tools required by the workman are the saw, axe, chisel, and hammer, with which—with the supplementary aid of nails, screws, and bolts—it is assumed that he can put together and fix the various framings of wood which are required, from time to time, to complete the skeleton of the building.

It must, however, be understood that the carpenter requires quite as good, and certainly as many tools, to fix in position the various finishings—whether they be doors and windows with their frames, dados, skirtings, or any other kind of moulding or framing—as the joiner uses in making, moulding, and framing together, in the shops, those several framed finishings ready to be sent to the buildings for the carpenter to fix in their proper positions.

It must also be borne in mind that quite as much care is required in fixing as in making all kinds of joinery, especially in mitring and scribing the various mouldings, etc., together—all joints in joinery having to be made with the same nicety and regularity, whether those joints be made by the joiner in the shops, or by the carpenter on the building, in position.

The carpenter, in fixing, must, of course, be acquainted with the same varieties of wood as the joiner (a full description of joiner's woods will be given later on); but in ordinary carpentry, or framing together of the rough carcase of a building, the following woods only are met with, as a rule, though perhaps others may be used in special cases, the woods being mentioned here in their order of precedence, from the point of view of their utility:—

1. *Pine*, under which name are included balk-timber of different kinds, and fir, in planks, deals, battens, etc. These are what are called soft woods, and found generally in cold climates.
2. *Oak.*
3. *Elm.*
4. *Teak* and *Greenheart.*

These three are generally called "hard" or "leaf" woods.

On the other hand, the joiner requires a *plane* in addition to chisels, saws, hammers, etc., to complete his work, which includes the doors, windows, and other external and internal finishings of a building, whether required for comfort, utility, or ornament. His business is to join and put together the finishings; and the woods on which he generally labours are:—

1. *Pine*, but of a "kinder" nature and considerably better quality than that required for carpentry.
2. *Oak.*
3. *Mahogany.*
4. *Teak.*
5. *Walnut.*

These four latter woods, being hard, more beautiful, and much more expensive, are only used in best work.

Before proceeding to a full description of each kind of wood, with its varying characteristics, uses, etc., it will perhaps be advisable to deal with a few general points, including the growth of the tree, the main characteristics of good timber, and its defects, the means of seasoning and preserving it, and a few remarks as to the selection of good timber, and some of the peculiarities which are to be avoided.

Wood in the Tree.—All trees which provide us with material for the carpenter and joiner's use are what are called outward-growing trees—that is to say, those whereof the gradually increased size is brought about by successive layers, which might be said to be formed around the circumference of the stem or trunk, and close underneath within the bark. Each year generally adds one of these layers or rings, and consequently they are called *annual* rings; but each ring is, as it were, double, being made up of two distinct layers of a different nature and colour. The darker layer is more apparent in certain kinds of timber, and is usually a source of weakness in a varying degree; inasmuch as being, for the most part, composed of resin, it is of a soft nature, with very little power of resistance to either compression or tension; while, on the other hand, the lighter-coloured layer is that which possesses the greater tenacity.

The growth-processes, of which these annular rings are the result, are briefly as follows: The tree, during the autumn and winter, having been to all appearances dead, when spring comes round absorbs, by means of its roots, a considerable amount of moisture out of the soil; and this, in the form of sap, ascends the cellular tubes of the tree, and causes the leaves and signs of life to appear. As summer advances the leaves become stronger and of more substance, owing to the carbon extracted by them from the air; and as autumn again draws near the sap, in its more substantial state, begins to descend, leaving a layer of wood immediately under the bark; then the leaves, owing to the loss of nourishment, drop off. This action takes place each year, so that the age of a tree (in ordinary climates) can be ascertained by the number of its annular layers or rings. In cold climates, where of course trees do not grow so fast, the rings are not so thick, and the inner or "heart" wood is more compressed; so that timber of slow growth is considered to be of greater strength. The "heart" wood or "duramen" is the strongest, best, and most durable part of the tree, the outside or sappy part being considerably weaker, and practically unfit for use.

In addition to the annual layers or rings just explained, trees have what are called *medullary rays*, which are thin and generally broken lines, radiating from the centre or pith to the bark, and *vice versâ*, as fig. 261. These medullary rays or *transverse septa* are not very easily seen in some woods, but in some kinds of oak they are very apparent; and if the wood is cut obliquely they form a very beautiful *figure*, as it is commonly called, but also known as *felt* or *silvered grain*, from its light-coloured, and hard, polished appearance.

It may be as well to mention that trees generally should be felled in the middle of the winter, when the sap has descended and the tree is at rest. There is also a proper age for the felling of trees, as the young ones are full of sap, and the old ones decayed at the heart; but only experience will enable one to judge of the proper time to fell, as the period at which a tree may be said to be at its prime varies from 50 to 150 years.

Good and Bad Timber.—The *characteristics* of good and the *defects* of bad timber may be dealt with simultaneously. Good timber should be cut from the heart wood of a well-matured tree, free from sap (of either white or blue colour), as well as from large loose or dead knots, shakes (whether they be cup, heart, or star shakes), rind-galls, and unevenness of colour. It should be regular, straight, and close in the grain, and when planed its shavings should be long and stringy; and it should shine when worked, smell sweet, and, when struck, give forth a clear sound; the fibres should be so straight and continuous that, when converted, very few of them would be cut through. The heart itself of a tree is much given to "shakes."

Wood is a conductor of sound, and the soundness of a log is often ascertained by the way in which it transmits a "tap" from one end to the other. Failure as a sound conductor, or the transmission of a dull sound, indicates decay.

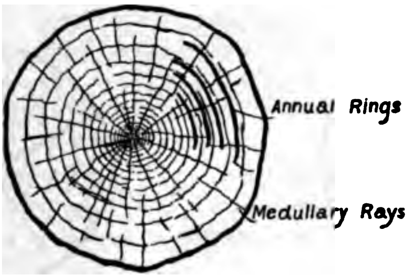


Fig. 261

Sap is the most common defect in the timber of to-day, and is the result of the converter's desire to get as much bulk of timber as possible out of his tree, and being thus obliged to cut outside the circle of the hard or heart wood into the sap. Sap is, therefore, found at the sides or edges of the wood. Sap can either be of a blue or white colour; the one is as bad in the end as the other. They both lead to decay, and in varnished work cause a dark stain. There is no cure for it, and it must be cut away.

Knots, of whatsoever kind, whether hard, loose, or dead, are a source of weakness, as they break the continuity of the fibres; but they are not so serious a defect when hard and sound, except in the centre of a beam, or where great tensile strength is required. The presence of a large quantity of knots is always a serious defect in timber.

Cup shakes are those which encircle the pith and separate the annual rings in a curved line, and, unless they are long and separate a large portion, they are not dangerous, *vide* fig. 262.

Heart shakes, the most common of shakes, occur at the centre of the tree, and radiate towards the bark, as fig. 263. These, of course, weaken the wood, and render it impossible to convert the tree into large-sized stuff.

Star shakes are similar to the last-named, but more numerous from the centre of the tree.

Rind galls are the result of the growth of the tree over a place where a branch has been improperly cut off. They usually take the form of irregular swellings.

Unevenness of colour.—This defect includes both "foxiness" and "doatiness," the former being a red or yellow stain, which betokens decay, and the latter a speckled stain foreboding the same thing, which is met with in American oak and beech.

Seasoning of Timber.—On the principle that prevention is always better than cure, we will deal first with the seasoning of timber, which is the next thing in importance to be attended to after the wood has been procured from a fully matured tree. The object of seasoning timber is to get rid of the sappy moisture which, as has previously been pointed out in these notes, is a great source of decay. This can be done by either drying up or driving out the superfluous moisture, a proceeding which of course reduces the weight of the timber. Tredgold maintained that the timber was not seasoned and fit for carpenter's use until it had lost one-fifth of its original weight; and for joiner's work he considered that it should have parted with moisture to the extent of one-third its weight before it was fit for best work.

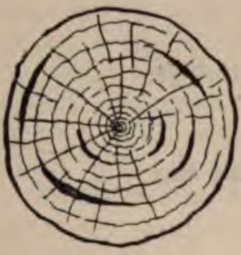


Fig. 262.

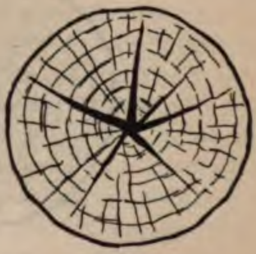


Fig. 263.

There are several methods of attaining this end, the chief of which are as follows:—

Natural seasoning is a very simple procedure, and consists of stacking the timber, after it has been converted, edgewise on perches, so that, while the air can have free access all round it, the sun and wet can only touch the edge.

The method of operating is briefly explained thus: One length of timber is reared edgewise, and alternately from the sills of B and D (fig. 264), which should protect the bottom of the board from the damp

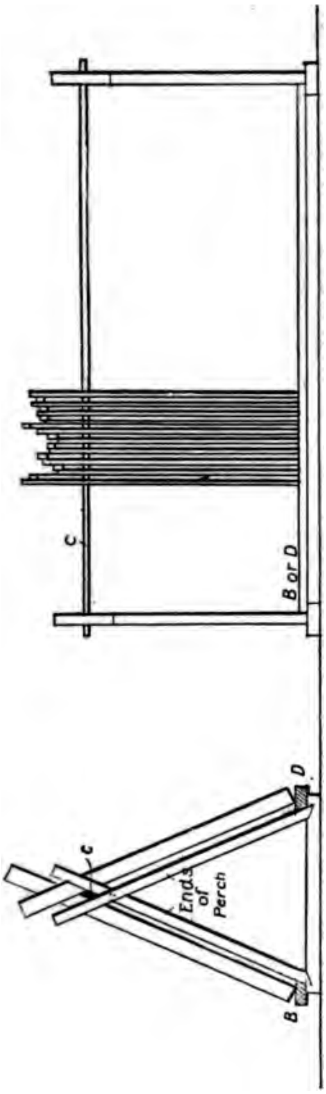


Fig. 264. about ¼ Scale.

arising to the cross-piece C; by which means they are secured from moving at the top, and the air can circulate all round the wood, except just immediately over the cross-piece, without exposing the width, the greater surface, to the weather.

Floor-boards and other thin woods are sometimes stacked on the flat, on bearers raised off the ground, with a lath between each row of boards, thus (fig. 265). They are generally covered over, on the top only, with felt or other waterproof material.

In large yards the timber, of all sizes, is stacked under covered sheds, whereas it is best perched in the open, if in a shady position.

The seasoning process requires, for complete drying, about a year, for every inch in thickness, for converted and sawn oak or other hard woods, when perched or stacked under ordinary circumstances, and for fir and other soft woods about half as long.

Next to the natural seasoning comes the *water seasoning*, which is a simple method of washing the sap out, though this is generally applied only to logs. It consists of submerging the whole of the timber under either ordinary or salt water; the former being preferable, as the latter water has a tendency not only to harden the wood, but also to attract moisture when in the work, inasmuch as salt is generally affected by any excess or variation of humidity in the atmosphere. The logs are kept wholly under the running water until the sap has had time to get washed out, then the logs are taken out, dried by the air, and cut to sizes; for unless they are dried before use they will be subject to dry rot.

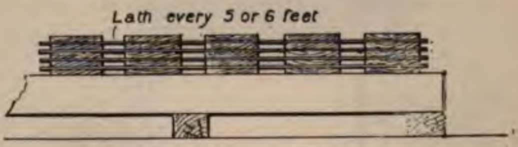


Fig 265 ½ Scale.

Boiling and steaming, or *the hot-air method*, are similar: that is to say, in the one the sap is supposed to be driven out by the hot water, and in the other by the steam or hot air. They are all quicker processes than either water or natural seasoning; but they are certainly more expensive, and, moreover, they have injurious effects on the timber, by reducing its strength and elasticity.

It may be as well to mention that many kinds of timber require more than one seasoning, because each time the surface is planed, or anything is taken off, the wood is apt to shrink, as the air seems to harden the outside, and form a casing to the inside, and thus prevent its penetrating the wood under ordinary circumstances. This more particularly applies to floor boards and joinery, where the least shrinking is noticeable.

Preservation of Timber.—The object in preservation of timber is to save it from rot, whether wet or dry. There are many different ways and patented methods of trying to prevent these forms of decay; but, before proceeding to explain them, it will be as well to say a few words on wet and dry rot.

Wet rot is really the decomposition of the wood, especially the sappy portions; and it takes place while the tree is standing, and also when the gases can escape; whereas *dry rot* occurs in the converted timber, and is generally brought about by fermentation, the result of confinement and lack of circulation of the air, which causes a fungus, similar to a cobweb, to encircle the wood and suck its very nature out, until it is reduced to a powder.

Wood is most subject to *dry rot* when in damp and warm situations, with no circulation of air. Ground-floor joists, with no ventilation, or with misplaced ventilation, are soon attacked by it. The ventilation should be placed where the air can circulate underneath the whole floor. The *corners* are generally ignored, and the result is soon apparent. The same result arises from timbers built into damp walls without a passage of air around them. Oilcloths also favour this form of decay, which is very difficult to get rid of. When once in a building it soon spreads all over. Dry rot, of course, renders timber dead as far as sound goes. A log may be good outside, while the inside is a mass of dry rot. This can be detected by the fact that it will not conduct a sound from end to end; or, in boring it, after the outside skin is penetrated, there is nothing but powder to resist the pressure.

The simplest method of preservation is, of course, to paint or tar the work, care being taken that the wood itself has previously been thoroughly seasoned, *or* the paint will keep the moisture in, and be itself the cause of decay. The same thing applies to *charring* the ends of posts, joists, etc., and *creosoting*. This latter is a process by which a mixture of oil and tar is forced (under pressure in tanks) through the pores of the wood. This is the most common, and perhaps the best, way of preserving timber which is required to withstand damp, especially sills and posts resting on or in the ground; but, at the same time, it is an objectionable method, because it makes the timber of a dark brown colour, almost black, and very greasy; and, moreover, the whole of the piece must be treated in the same way, so that nothing can afterwards be done to make it look respectable. It will take neither paint nor whitewash. In this respect it is that *charring* is far superior, though not so generally used, as it is only necessary to char that portion of the timber which is required to withstand more than ordinary moisture.

Among the patent processes the most common are :—

Burnet's, by which the timber is soaked in a watery solution of chloride of zinc, in the proportion of 4 gallons of water to 1 lb. of chloride of zinc. The advantage of this process is that it is colourless, and protects the heart; whereas the creosote is more greedily taken by the sappy part. This mode is very much used for wood-blocks for paving.

Boucherie's method consists of forcing sulphate of copper through the pores, but not in a tank, as in creosoting, the liquid being in this case poured into a hole at the top of the log, and the weight of the liquid coming from a tank above forces the other through. The disadvantage of this method is that the wood has to be cut into to allow the liquid to get a start.

Peters' (of Derby) *Carbolenium* is a mixture similar to creosote, which is put on the ends of joists. It can be applied with a brush before the joist is placed in the building; and it is said to be a great success. It is also used on all wall-plates and other members generally, whenever built within or into the walls.

Kyanising consists of injecting corrosive sublimate, dissolved and diluted with water, into the wood. It is said to be efficacious in preventing rot, and is especially used for seasoning railway sleepers, having an advantage over creosoting, in that it does not make the wood so inflammable.

Deal or Fir.—*Pine, red and yellow fir*, or "deal," as it is commonly though incorrectly called, is obtained from the northern pine, a fir-tree which is grown a little in Scotland, but chiefly in Norway, Sweden, and Russia. It is either of a red or yellow colour, very full of resin in quickly grown stuff, works easily, and is used for all ordinary purposes in this country, whether for joinery or carpentry. The ordinary trees are cut up into widths of 7, 9, and 11 inches, by 2½, 3, and 4 inches in thickness, and in from 20 to 25-feet lengths, according to district; but the best and largest trees are converted into "balk timber," which commands a higher price, owing to its scarcity, and varies in size from 12 to 18 inches square, and up to 35 feet in length.

White deal, cut from the spruce fir, has not the strength and durability of the red or yellow kind; it is of a very dry fibre, full of loose dead knots, and only fit for painted work in common joinery.

Fir, of whatever kind, has very indistinct medullary rays, and the closer the annual rings the stronger it is; though, at the best, it has very little bearing strength, or power, or resistance, owing to the trees being felled before they have arrived at the age of maturity.

Balk timber is imported chiefly from the ports of Memel, Dantzic, and Riga on the Baltic; while the planks, deals, and battens—as the 11-inch, 9-inch, and 7-inch widths are respectively called—come from Norway, Sweden, Northern Russia, and Finland, countries where the coldness of the climate does not allow of the trees growing to a size suitable for balk timber.

Memel balk timber is of a coarse nature, neither of slow nor quick growth; and only suitable for carpentry and engineering purposes, owing to its coarse grain, and the large quantity of resin which it contains.

There are two or three qualities of this variety, and it is generally considered the strongest timber in the market, on account of its straight fibres and freedom from knots and shakes.

Dantzic balk timber is chiefly grown in Prussia, and is of a more knotty nature than Memel, though harder, cleaner, and closer in the grain; but it is nevertheless considered inferior.

Riga balk timber—almost unknown now in the market—is similar to the other two qualities, being of a very straight growth, comparatively free from sap, but rather shaky.

Norwegian planks, deals, and battens are distinguished by the blue stencil marks on their ends. They are either white or yellow, and not of a very first-class quality; being only fit for carpentry and scaffolding, though a large quantity comes into this country converted into floor boards, match-boarding, etc. Drammen and Christiania are the chief ports of shipment.

Swedish planks, deals, and battens are imported from Gefle, Soderhamn, Stockholm, and many other ports, and are distinguished by a red stencil mark on their ends. They are superior to Norwegian, the best qualities being very sound, even, and comparatively free from sap. They are used chiefly for carpentry, floors, etc.

Russian planks, deals, and battens are more of the red quality, far superior to either the Norwegian or Swedish, and used chiefly for joinery; being harder, brighter, cleaner, stronger, freer from sap and knots, and of a kinder nature to work. The Petersburg, Archangel, Onega, and Uleaborg (Finland) are the best kinds, and are distinguished by marks cut in the ends by a branding hammer.

Fir, of whatever kind, weighs on the average about 1 ton per 50 cubic feet.

The working stress of good Memel, per square inch of section, is about 12 cwt. in tension, 10 cwt. in compression, and 12 cwt. in bearing; compared with 10 cwt., 7 cwt., and 7 cwt. respectively for the ordinary inferior qualities of fir.

America and New Zealand both grow trees of the pine class, but the wood they produce is inferior to that from the Baltic in strength; though it is freer from knots and other imperfections, kinder in nature, of wider width, and more suitable for joinery and cabinetwork. The chief kinds are: the Canada red pine, which bears all the usual qualities, except that it is inclined to be knotty, and is not very wide. American yellow pine, though expensive, is an invaluable wood to joiners in this country, as it has all the good qualities of a joiner's wood, with a kind nature, bright, close, and easy grain, comparative freedom from knots, and can be procured in very wide widths, so that it is excellent for panelled work. It is not very strong or durable in this climate, but passable when painted.

Pitch pine is grown in the Southern States of North America, the best coming from the neighbourhood of Savannah. It is a very red wood owing to the large amount of resin it contains, and consequently is difficult to work, as the viscidity soon affects the joiner's tools. Its hardness makes it a valuable wood for wear, while some of it has a most beautiful appearance, which renders it suitable for best varnished work, It is heavy in weight, but very durable and strong, though subject to shakes and sap. Its annual rings are very conspicuous, its grain straight, and comparatively free from knots. On account of the resin it contains it will not take paint properly, nor yet creosote. It is imported in logs of 12 to 18 inches square, and can be procured in very long lengths, sometimes as long as 70 feet.

Oregon, *Quebec*, and *St. John's pine* are other names given to North American pine, distinguishing the districts whence it comes.

Kawrie pine, found in New Zealand, is a hard, pink-tinted wood, with a very close, even grain, free from knots and other defects. It can be procured in very wide widths, will take polish well, and is most suitable for table tops, cabinetwork, etc.

Elm comes from a British-grown tree of the same name, can be procured in wide widths, and withstands damp, though not alternate wet and dry atmospheres; its grain is very coarse and tough, shakes are almost unknown to it, but rotten holes are often met with; it is of warm brown colour tinged with purple, and the sap of a light cream. Elm is chiefly used for piles and similar work exposed continually to wet, and in damp situations, pump-planks, stable divisions and doors—the latter on account of the dislike that horses have to biting it; and its great resisting power renders it very useful for curbs, bumping-blocks, etc.

Oak.—The chief varieties of this wood are English, Stettin, Wainscot, and American. It is very hard, tough, close, and durable, and is used by both carpenter and joiner. It is of a light brown colour, has medullary rays in it to a conspicuous degree, in addition to the annual rings, which should be close and regular to denote the best quality.

The English variety is obtained from either the "stalk" or "cluster fruited" trees, the latter being the darker in colour, heavier, tougher, and more durable quality of the two. Both kinds are much used in this country, where strength and durability are the chief requirements, especially for window and door sills, wall-plates, roofs, steps, posts, fencing, etc. It is hard to work, especially when young and wet, being more of a carpenter's than of a joiner's wood, is very elastic, and can be easily bent when steamed.

Its weight is about 40 cubic feet per ton, and its compressive strength may be taken at 13 cwt. per square inch; bearing strength at 25 cwt., and tensile strength at 16 cwt. These results are based on the same standard, or working stress, as other safe quotients given in these notes.

The gallic acid which oak contains corrodes all iron with which it comes in contact; wherefore, screws, bolts, etc., to be used with it, should always be galvanised.

Stettin oak, so called after the port whence it is shipped, is at first sight similar to the English species, and is very often substituted for it, but it is not nearly so strong or durable. It is softer and easier to work, though inclined to be woolly. Loose dead knots and decayed pores are very often met with in it, and when it is wet and unseasoned it gives off a sour odour. It is imported in logs, and is employed for the same uses as the English.

American oak has a pink tinge in it, and is similar in texture to the last named, though sound, hard, tough, and elastic. It is used as a substitute for English oak.

Wainscot oak is chiefly shipped from the Baltic ports, Riga and Dantzic. It is imported into this country in logs cut "on the quarter." This kind of oak is grown chiefly in Poland and Austria, and is essentially a joiner's wood, being more expensive than the other kinds, and used only for best internal finishings. It is hard, of a light brown colour, with a close, compact, and even grain, though it is kinder in nature and less durable; knots are seldom met with in it, and it is the absence of knots that leads some people to note the difference between it and the best Stettin, which is, in fact, very much like it in most other respects. Wainscot is full of little pores, and sometimes white specks; the medullary rays are very conspicuous, if it is properly converted "on the quarter," and give it a beautifully figured appearance. The "Crown Riga" is often specified as the best quality. It is used for all kinds of joinery and cabinetwork, as well as for flooring, and will take polish well.

Teak is both a carpenter's and joiner's wood, found in Southern India and Burmah, where it is sometimes called the Indian oak. It is very straight in the grain, has no medullary rays, and is of a warm brown colour, tinged with yellow, in contrast to the purple tinge of elm. Teak is very brittle, whereas oak is tough. It has a peculiar smell, but does not corrode iron; it never swells, and is as strong as oak, free from knots, but subject occasionally to shakes at the heart. It is used for window-sills, treads to steps, bumping-blocks, and the best kinds of joinery. Railway companies use a great deal of it for carriage doors, on account of its non-liability to swell, and it is much used in shipbuilding. It will polish well.

Greenheart, found in the North of Southern America, is very often used as a substitute for teak, being much cheaper, and at the same time possessing the qualities of teak—viz., a fine, hard, and close grain, and great strength and resistance to crushing.

Mahogany is imported in very large square but short logs from Honduras and Cuba, the former being very much softer than the latter, and easier to work; in fact, some of it, called "Baywood," is very little more costly to work than deal. In colour it is a light mixture of red, brown, and yellow; shiny, close, hard, and yet kind in grain, free from the general defects, but it will not weather, and is only used for joinery, table-tops, handrails, and internal best finishings. It will take a nice polish.

Cuba, or Spanish mahogany, is considerably harder than the last-named variety, darker and richer in colour, full of little pores and silvery specks—due to the presence of lime—which dull the joiner's planes. It is far superior to the other kinds, more expensive, harder to work, and is only used for the best polished work.

Walnut is of two kinds, Italian and American, very different from each other in quality and nature. The Italian is really a cabinet-maker's wood, though occasionally used in the best of joiner's work. It is much harder, closer, and of a brighter colour than the American. It is principally used for piano cases and best cabinetwork; while the American is made up into doors, windows, dadoes, and other best joinery finishings—the colour being a *dull* light mauve, though it is often called "American *brown* walnut," being imported from New York, while the "American *black* walnut" is imported from Quebec in Canada.

Beech, the only other wood which is really of any *great* use to the building trades, is a hard, close, light-coloured, and speckly wood, obtained from the English tree of the same name. It is chiefly used for sinks, drainers, etc., where its hard, non-absorbent properties are of advantage; and the handles of carpenters' and joiners' tools are made of this kind of wood.

Ash, an English-grown wood, is remarkable because it has apparently no sapwood. It is tough, though easily worked, and very durable in a continually dry atmosphere. It is of a brownish-white colour, and used chiefly by cabinetmakers, on account of its elasticity and flexibility, which render it unsuitable for building purposes.

Sycamore is a white or yellow-coloured wood, from the *plane* tree, found in the North of England. It is of a very compact, firm, and durable quality, and will not warp. Builders scarcely ever use it, except for patterns.

Birch is another hard, English-grown wood, being more of a builder's wood than either of the two preceding kinds, as it is often used for handrails, stair-treads, etc. It is of a light yellow, speckly colour, very close and even in the grain, and sound. It is much used in the manufacture of furniture.

CHAPTER VIII.

WOOD FLOORS.

Naked Floors and Floor-boards—Single Floors—Floor Joints—Double Floors—Framed Floors—Flooring.

Naked Floors and Floor-boards.—Wood floors are, practically speaking, made up of a skeleton framing, called "naked flooring," surrounded and supported by a brick, stone, wood, or iron enclosure, and covered by boards of different kinds, to form a close and level platform above an open space.

The floor-boards are of various and more or less intricate sections, but one and all could be used at the same time as a covering to each of the different kinds of naked flooring, without any real detriment to the strength of the floor as a whole, provided the various sections be each of a sufficient and the same thickness.

Naked floors are really of three classes, though there may be different ways of carrying out the principles which distinguish one class from another. The simplest and most common class are called *single* floors, consisting of common joists only placed 12 or 13 inches apart, or 15 to 16 inches centre to centre, forming a bridge from wall to wall to support the boarded floor of the room above and the ceiling of the room beneath. It is this that gives the name of *bridging* joists to those joists which in all classes carry the floor-boards. The other two kinds of naked flooring are called *double* and *framed* floors, each of which will be fully described in the course of these notes later on.

Single Floors.—Single floors are suitable for all spans up to 16 feet, though they must be strutted after the span exceeds 8 feet. They are the simplest, cheapest, and strongest kind of naked floor, consisting, as before noted, only of the bridging or common joists, spanning from wall to wall, and carrying the flooring above and ceiling beneath. These advantages are, however, accompanied by the following disadvantages, which sometimes, in special cases, predominate :—

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1. The ceilings are apt to crack, on account of the sagging of the bridging joists, when in long lengths.

2. Wood being a conductor of sound, these joists, having no intermediate space between them, and carrying both the floor of the one room and the ceiling of the other, conduct the noises from one room to the other.

3. The joists, going from wall to wall, and having no other supports, distribute the load of the floor equally along the whole length of two of the enclosing walls, whether the wall is one solid mass or full of openings, in which case either the joists have to be carried by plates or lintels built in over the doors and windows in the wall beneath, or they have to be "trimmed" round them. Both methods cause weak points in the construction of a building.

The joists of the ground floors of buildings, when not above cellars, need not be so strong as for other floors, because dwarf sleeper walls, which reduce the spans, can be built on the ground to carry the wall plates which support and distribute the weights and pressure of the bridging joists.

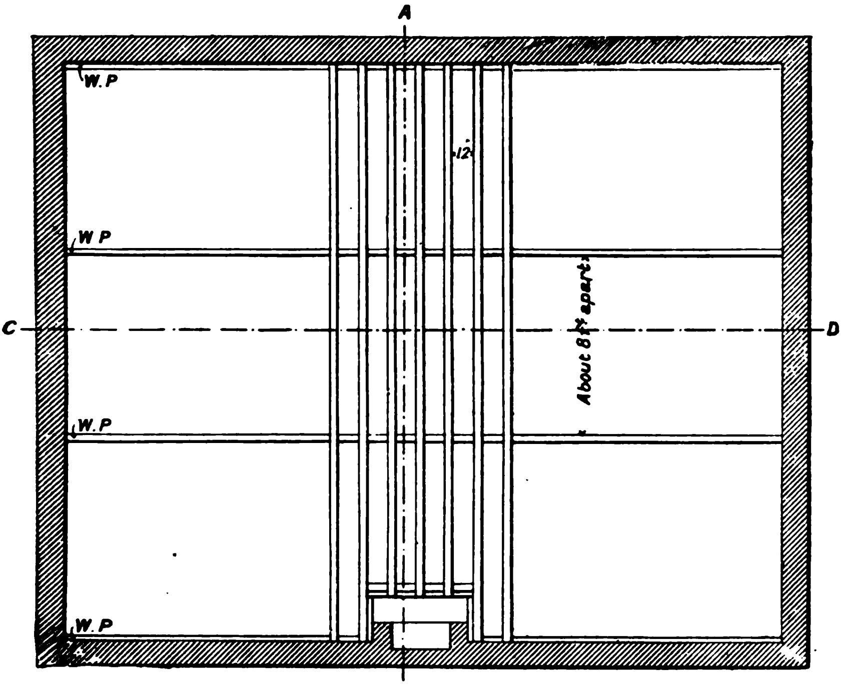
Fig. 266, in plan and sections, illustrates a ground floor supported by simple naked flooring, consisting of bridging joists, B J, carrying the floorboards from wall to wall, with intermediate dwarf walls to lessen the span and carry the wall plates, W P, to which the bridging joists are secured. The dwarf or sleeper walls both render the floor more rigid, and effect a saving of timber

A damp-proof course must always be put under the wall-plates, to prevent the damp arising; and it is better that these ground-floor wall-plates should be of oak.

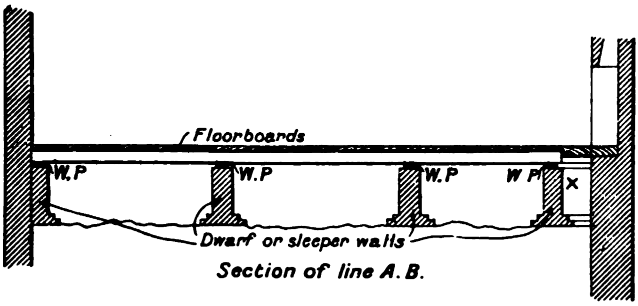
It should be noted that the wall-plates, W P, on the outside main walls, are not built into the main wall, but supported on sleeper or dwarf walls; inasmuch as the building-in of all wall-plates into the carcase walls of a building is held to be objectionable, on account of the dampness of the walls soon causing them to rot. It is the best plan to put the joists on two rows of hoop-iron, so as to distribute the weight to the extent required in the walls, or to support the wall-plates on corbels or over-sailing courses projecting from the main walls, care being taken to anchor the ends of the joists to the walls by means of iron, so that the enclosing walls are tied together by the joists.

Where fireplaces occur in ground-floor rooms it is usual to build fender walls round them, as X on section A B, fig. 266, to carry the wall-plates, and thus save trimming, which will be explained later on.

When single naked floors are used above other rooms it is obvious that the only support the bridging joists can have is the enclosing walls; and consequently it is necessary that the joists must be stronger, in proportion to the distance between the walls which have to carry them.

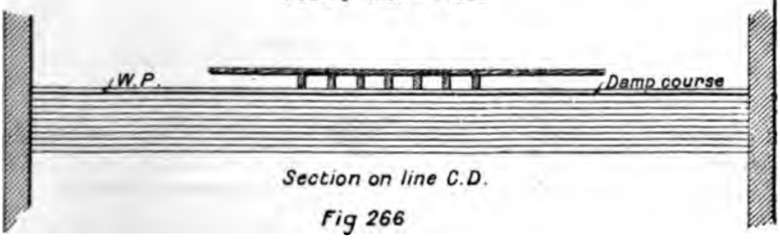


Plan



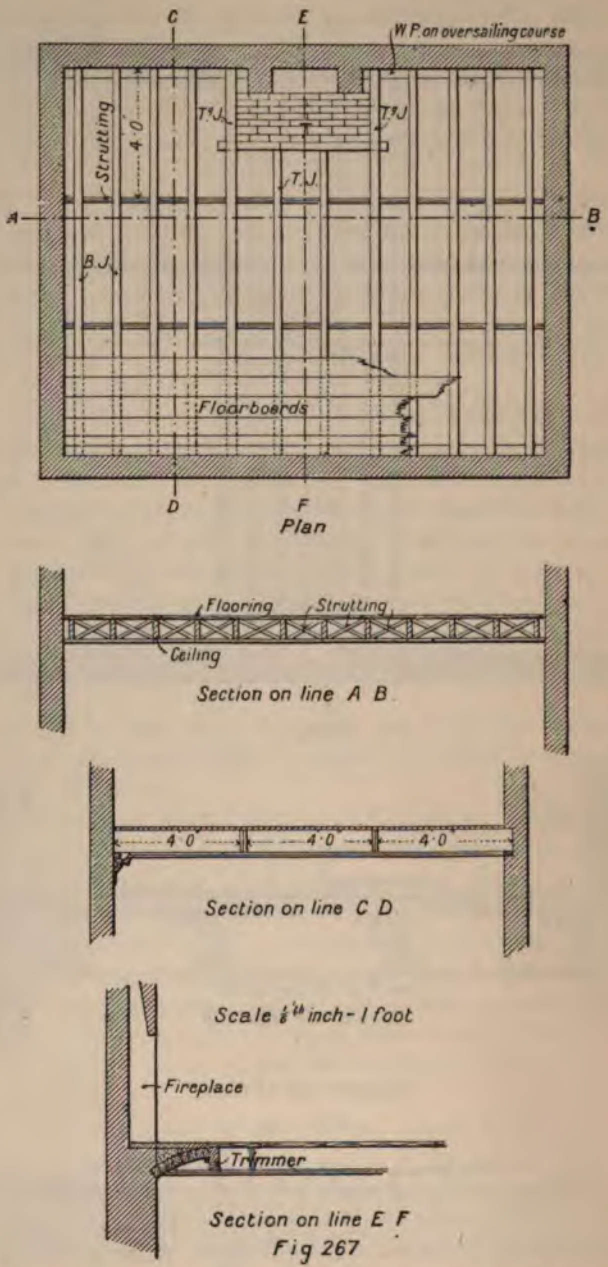
Section of line A.B.

Scale $\frac{1}{8}$th inch - 1 foot



Section on line C.D.

Fig 266



Plan

Section on line A B

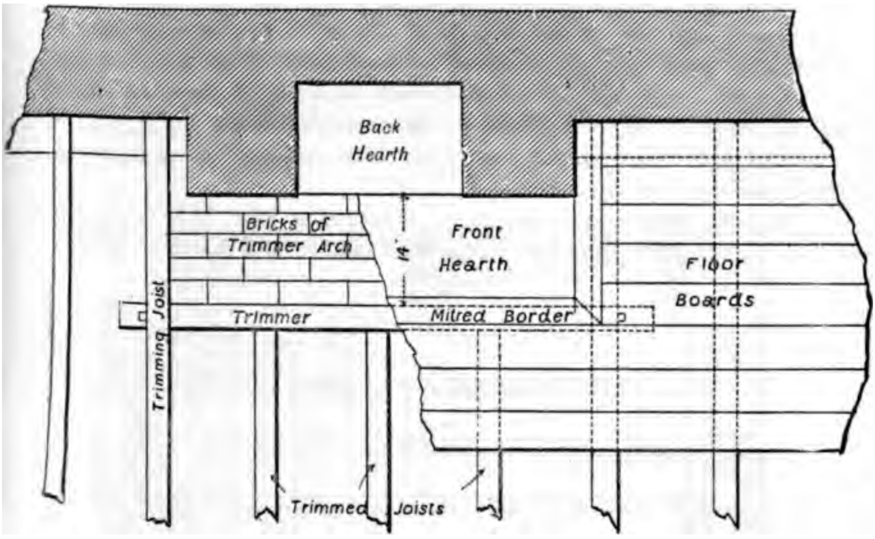
Section on line C D

Section on line E F

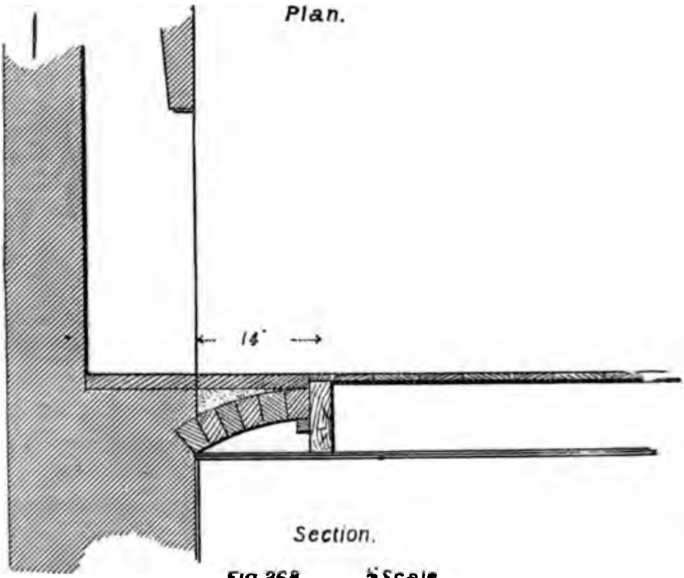
Fig 267

Fig. 267 illustrates, in plan and section, a single floor, carryin boarded floor above and ceiling beneath.

It will be seen therefrom that the bridging joists span from wall to wall, a distance of 12 feet, and carry the floor above and the ceiling below.



Plan.



Section.

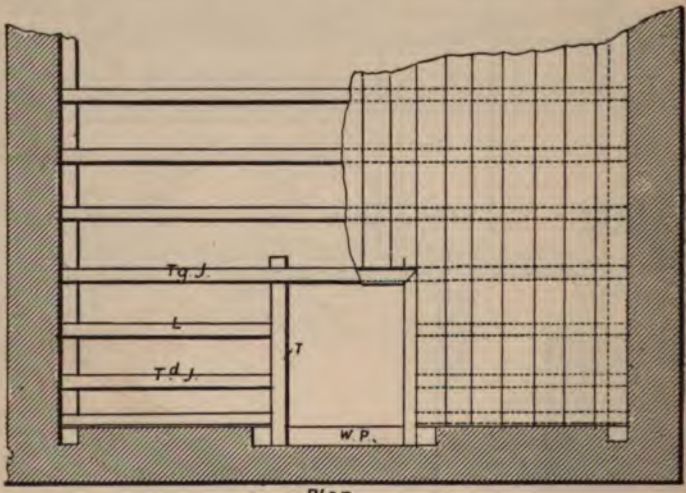
Fig. 268 ½ Scale

The ends of the joists rest on the wall-plates, W P, which are either built in the walls, as shown on the right-hand side of section C D, or rest on two courses of brick oversailing, as on the left hand of the same.

When the cornices below allow of the wall-plates being put on projections, and not built in the walls, that is the best, as the joists can be nailed to them; but when this cannot be done, it is better—as wall-plates built in soon decay—to lay the ends of the joists on two rows of hoop-iron, instead of on the wall-plates shown on the right-hand side of section C D.

On account of the risk of fire to which the building would be exposed if the ends of the joists rested on or near the chimney breast, it will be noticed on the plan, fig. 267, that the joists are trimmed round the fireplace to avoid any such risk.

A joist, stouter in width, called a trimming joist, T J, is placed an inch or two away from the side of the breast; and at 14 or 18 inches away from the face of this breast—according to the width required for the hearthstones—another joist, called a trimmer, T, is placed, running parallel to the face of the breast, and the ends of it are framed into the trimming joists, T J; and along the trimmer, in equal spaces of about 15 inches, from centre to centre, the trimmed joists are framed, with the other end resting on the supporting wall.



Plan

Fig. 269 ¼ Scale.

The plan and section, fig. 268, are intended to illustrate the explanation just given of *trimming* round fireplaces.

Fig. 269 will show the student how to trim round well-holes, trapdoors, and other openings, where the bridging joists run in a different direction.

Before proceeding to define and illustrate joints usually met with in single floors, it will be as well to explain one or two items which, though belonging to other kinds of floors as well, are connected with single floors.

Herring-bone strutting, *cross-nogging*, or *stemming*, is a means of strengthening and stiffening the bridging or common joists, and consists of small pieces of 3 × 1-inch or 3 × 2-inch stuff, fixed diagonally between the joists, as fig. 270.

There are two independent lengths in a row of it, as A A and B B, and they stretch from wall to wall, thus forming one continuous connection or support between the walls, and rendering each joist perfectly stiff—one row abutting on each side of the top of the joist, and the other at the bottom thereof. A row of this strutting, consisting of two courses, should be inserted every 4 feet apart where the span exceeds 12 feet.

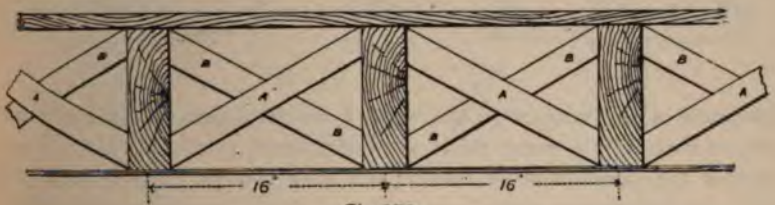


Fig 270

Solid strutting or stemming is an alternate method to the latter, and used in a similar way for the same, and it consists of a solid piece of wood the depth of the joist and 1½ inches thick, let in between the joists in one continuous line from wall to wall.

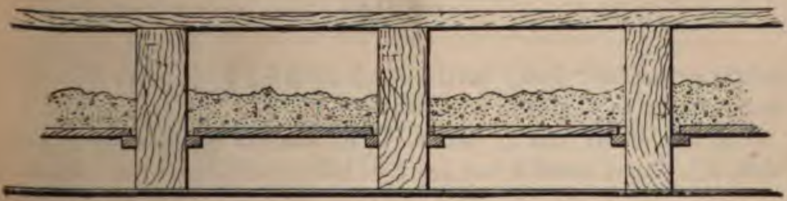


Fig 271

Pugging is supposed to be a remedy for the prevention of sound being conducted from one room to another by means of the floors. On each side of the joists 1¾ × ½-inch laths are nailed from wall to wall; and resting on these laths, between the joists, the *sound boarding*, as it is called, is laid, to carry the mixture which is to deaden the sound. (See fig. 271.)

This mixture is laid on the boards to a thickness of about 3 inches, and it consists of either ordinary mortar, with an admixture of hay, or of sawdust or ashes, or of asbestos or silicate cotton in slabs.

Another method is to nail cedar-felt from joist to joist, as on sketch (fig. 272), and fill in the space with sawdust.

Some of these kinds of pugging cause the joists to rot, owing to the dampness of the mixture or the want of air-circulation which they entail; and, to obviate this, some floors are constructed specially with a view to prevent the conduction of sound; but they involve extra expense, and raise the building a very little higher. Some people would call the method a "double" floor; but this is not done for the purpose of strength, though it may be double in construction.

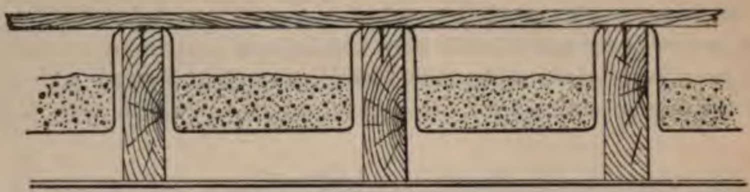


Fig 272

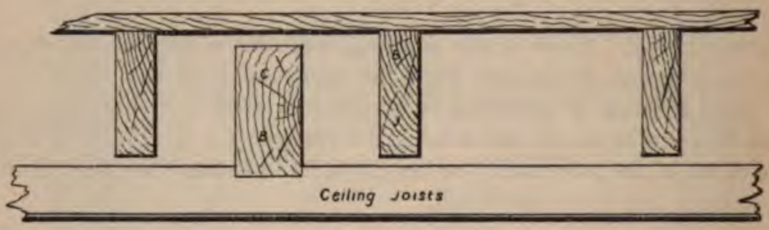


Fig 273

Fig. 273 shows ceiling beams, C B, inserted between the bridging joists, B J, placed about 8 feet apart, to carry the ceiling joists; which, it will be seen, make the ceiling independent of the floor and not liable to be affected by any vibration of the floor itself.

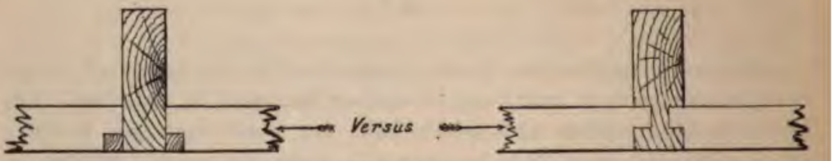


Fig 274

Floor Joints.—All joints in carpentry should be made in such a manner that the timbers are weakened as little as possible by loss of wood; and wherever one bearing timber has to support others it is of great advantage, if possible, to nail fillets on to the sides of the timber, and notch the others over it (as figs. 274 and 275), to avoid weakening the one by the mortises to take the tenons of the other. The weaker method is shown on the right, and the preferable and stronger method on the left.

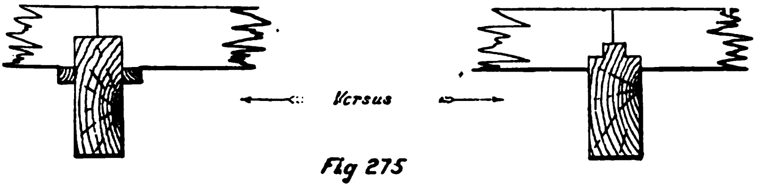


Fig 275

Wall-plates, when not of sufficient length to go the whole length of the wall, are connected by *scarfs* (fig. 276), a wedge-shaped piece being cut out of each end, so as to fit one another when connected; *and where they return at angles* the connection is then made by *halving*, or *bevelled halving*, the two ends, as shown in fig. 277.

The *halving* process consists of cutting a piece off the end of each plate, across their entire width, and to half their depth; while in the *bevelled halving* the remaining parts are bevelled alternately, to fit one another and prevent any displacement of the joint.

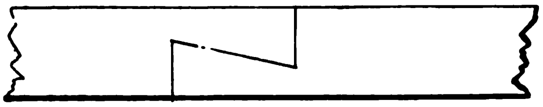


Fig. 276

The *dove-tailed notch* is made by cutting halfway into each plate, with one side of each plate left straight and the other dovetailed, to prevent its being drawn out, as fig. 278.

The joists are generally spiked on to the wall-plates, or they are *notched* and nailed on to the plates (fig. 279).

Another method of attaining the same object is by *cogging*—though it is seldom used except for beams—when a "notch" is made in the underside of the beam, which fits on to a piece left on the wall-plate, which is similar to the cog of a wheel; whence the method is called "cogging" (fig. 280).

The only other joints met with in single flooring are those connected

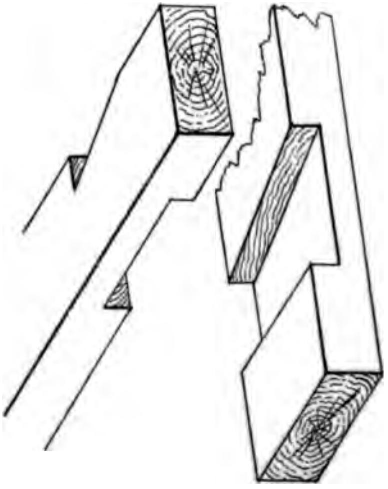


Fig 278

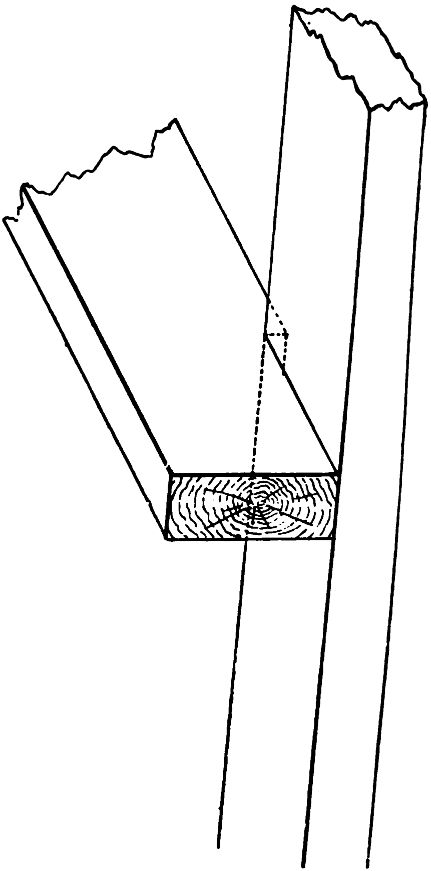
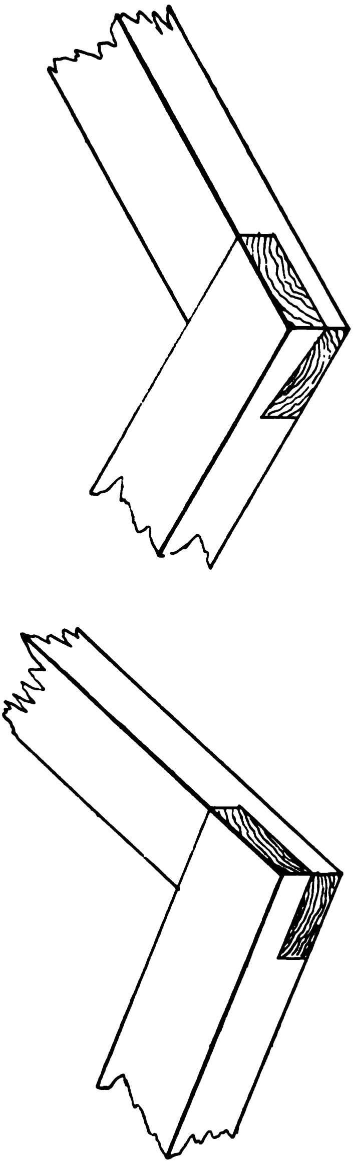


Fig. 279.



Halving.

Bevilled Halving

Fig 277.

with trimming, and they apply as well to double and framed floors as far as the joists are concerned.

The joint between the trimmer and the trimming joists is called a *tusk tenon*, and illustrated by fig. 281, where it will be seen that the tenon, T, with the horn, H, and tusk, K, are cut out on the trimmer and let into a similar mortise, with the bearing or shoulder, S, on the trimming joist. After they have been tightened up together, *in situ*, a pin, P, is driven through a mortise in the tenon, T, as shown on the plan, fig. 282.

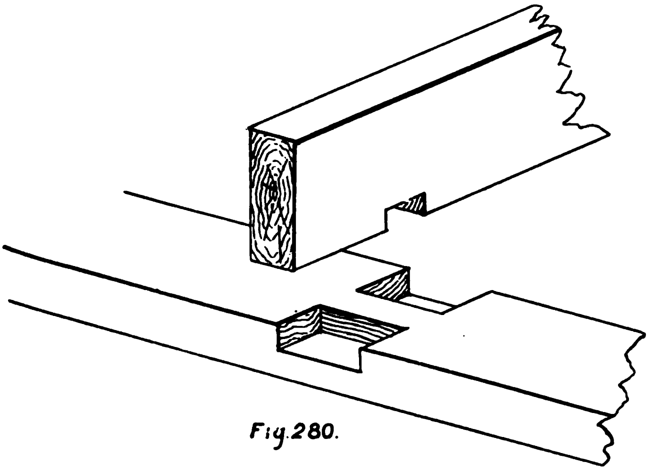


Fig. 280.

The trimmed joists are framed into the trimmer by means of a joint similar to the last, only without the tenon being pinned, as shown in fig. 283.

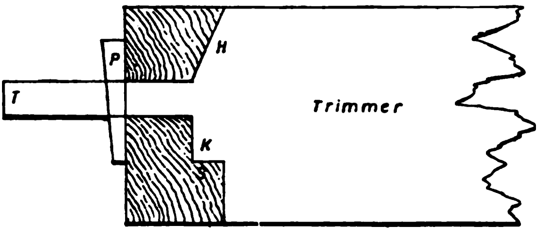


Fig. 281.

Single naked flooring can be made quite strong enough for ordinary purposes over spans up to 16 feet, the strength of the floor depending chiefly on the depth of the joists, the safe strength and depth of which can be ascertained by "halving the span in feet, calling the quotient inches, and adding 2, which gives the depth required in inches." For example: the span being 10 feet, 10 feet ÷ 2 = 5 inches; 5 inches + 2 = 7 inches; therefore the depth must be no less than 7 inches, and the width $2\frac{1}{2}$ or 3 inches, according to circumstances; although little depends on the width, which is usually either 2, $2\frac{1}{2}$, or 3 inches. Trimmers and trimming joists of course need to be stronger, and it is usual to add 1 inch in thickness for them, or $\frac{1}{8}$th of an inch for every trimmed joist which need only be the same as the common or bridging joists.

Double Floors.—*Double* floors are used for spans of over 16 feet,

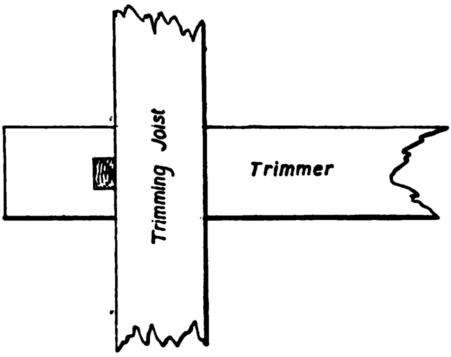


Fig. 282.

to reduce the bearing of the bridging joists; for which purpose large beams called *binders* are placed—at intervals of every 10 feet, at most—between two of the walls and resting on the other two.

Double floors have the advantage of stopping the passage of sound, and rendering the bridging joists stiffer, so that the ceilings are not so liable to crack; and they also act as a tie to the walls of the building.

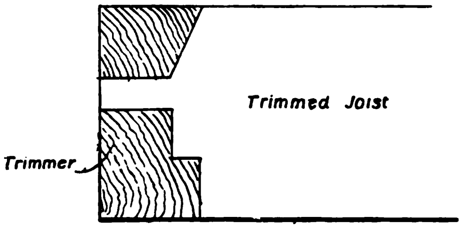
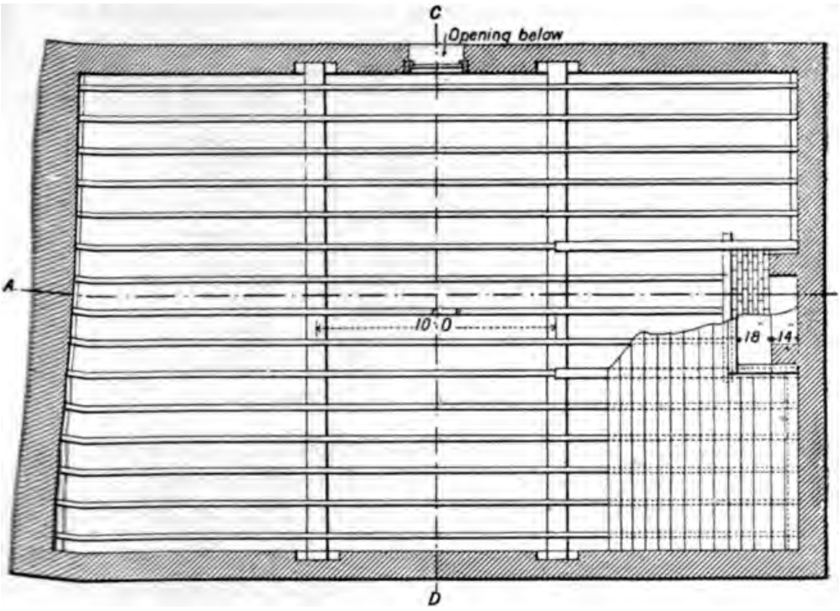


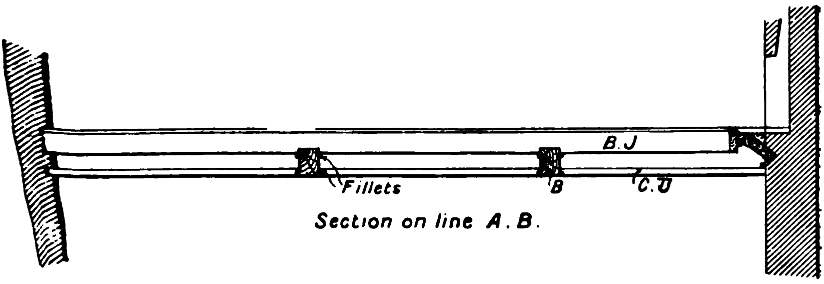
Fig. 283.

On the other hand, they are more complicated in construction, which is always a defect; and, moreover, they raise the building and add expense thereby.

It should always be borne in mind that, as the "binders" collect the weight of the floor off the "bridging joists," they must be supported by solid masonry, brick, or ironwork—not placed over openings, as can be done with the ordinary joists. This is sometimes an advantage, especially where the walls beneath are full of openings. In such cases the "binders," carrying, as it were, the whole weight of the floor, can be placed over solid parts, sometimes specially designed for them; and the weaker parts above the openings can be left without any weight at all on them.

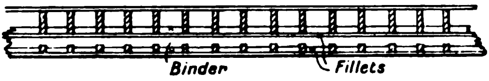


Plan



Section on line A.B.

Scale $\frac{1}{8}$th inch - 1 foot



Section on line C D

Fig 284

In fig. 284 the plan and sections are illustrations of a double floor.

The space between the binders is called a *Case Bay*, and that between the binder and the wall a *Tail Bay*.

The "binders" should rest on stone templates on the walls, in a little recess, as fig. 285, so that the air can circulate round the wood, as to build any timbers into the damp walls is always conducive to rot.

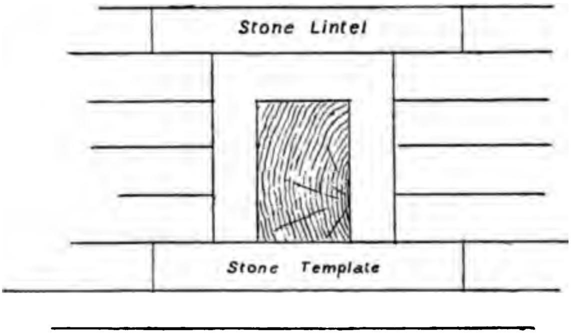


Fig 285. 1" Scale

The joints used in this flooring are similar to those last described for single floors, the only addition being that whereby the bridging joists, etc., are fixed to the binder. The joists are generally notched on, as fig. 286; but this is a bad way, as the notches, being cut out of the "binder," weaken it to a great extent.

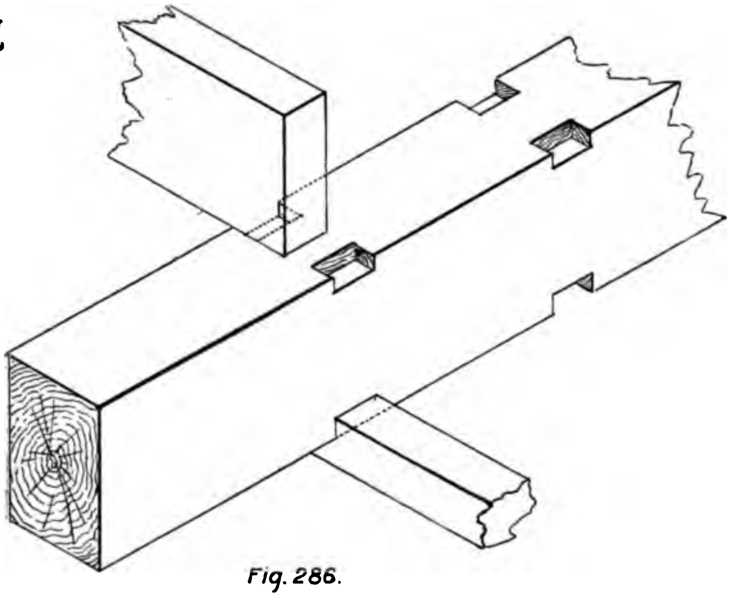


Fig. 286.

The better plan is, as before explained, to nail fillets on the sides of the binder and notch the joists, instead of the binders which carry the joists and the floor, as fig. 287.

Sometimes the ceiling is put on the underside of the bridging joists where the height of the rooms below will not allow of special ceiling joists; in which case the "binder" is planed and moulded to prevent its being so

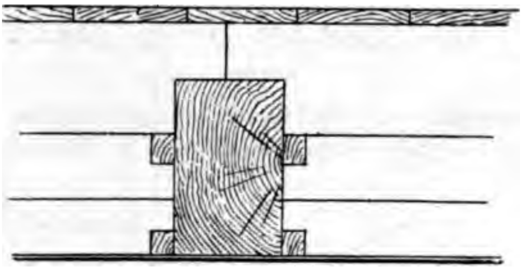


Fig. 287. *1" Scale.*

great an eyesore, and it has to be notched for the bridging joists, or they are cut away where they take the bearing, a process which in no way weakens the framing (*vide* fig. 288).

The *chase-mortise* is also a joint that is employed in this kind of floor. It consists of a tenon cut on the ceiling joist and put into the

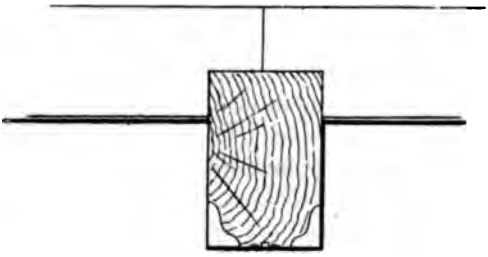


Fig. 288. *1" Scale.*

mortise which is cut out of the fixed "binder" with bevelled slide into it, as shown in fig. 289. This joint is very handy in cases where the "binders" (or mortises) are so placed that the tenon cannot be fixed in as usual. It is also used when the space allotted to the depth of the floor will not allow of the ceiling joists projecting below the binder.

Binding joists are only required for spans above 16 feet, unless under exceptional circumstances. The best way to impress on the memory the sectional dimensions required for the different spans is to take 5 inches wide and 8 inches deep as the standard for 10-feet spans, and to add

1 inch in depth and ½ an inch in width for every additional 2 feet. Thus we should have the following dimensions:—

8	inches deep by	5	inches wide, suitable for	10-feet	spans.
9	" "	5½	" "	12	"
10	" "	6	" "	14	"
11	" "	6½	" "	16	"
12	" "	7	" "	18	"
13	" "	7½	" "	20	"
14	" "	8	" "	22	"

Framed Floors.—"Framed floors" are used for spans of 24 feet and over, and consist of girders placed 10 feet apart, in addition to the binders,

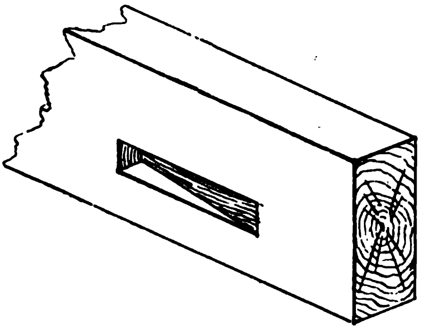


Fig. 289.

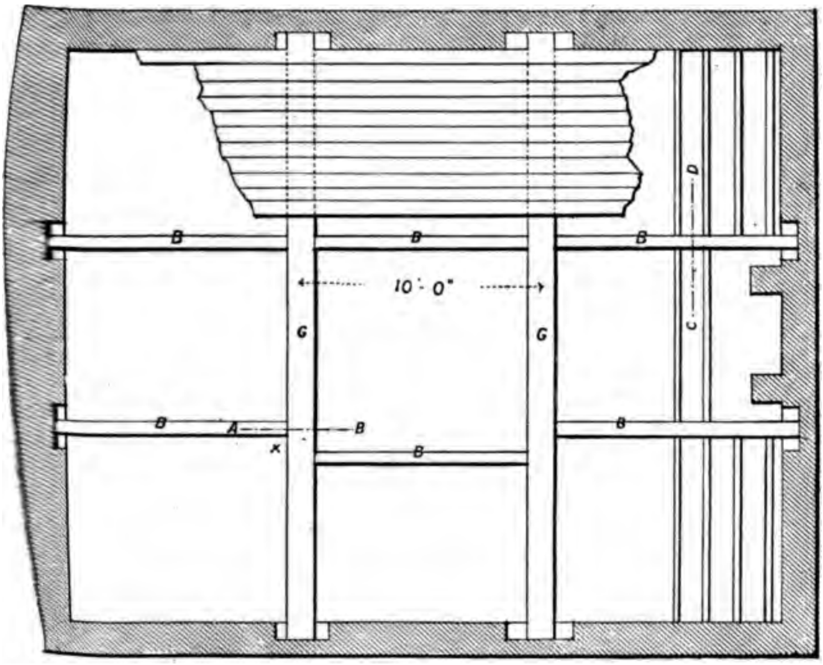
bridging and ceiling joists known in connection with other kinds of floors (*vide* fig. 290).

To save repetition, it may be said that framed floors have the same objects, advantages, and disadvantages, as double floors—but of course in a higher degree—and the same rules apply to both.

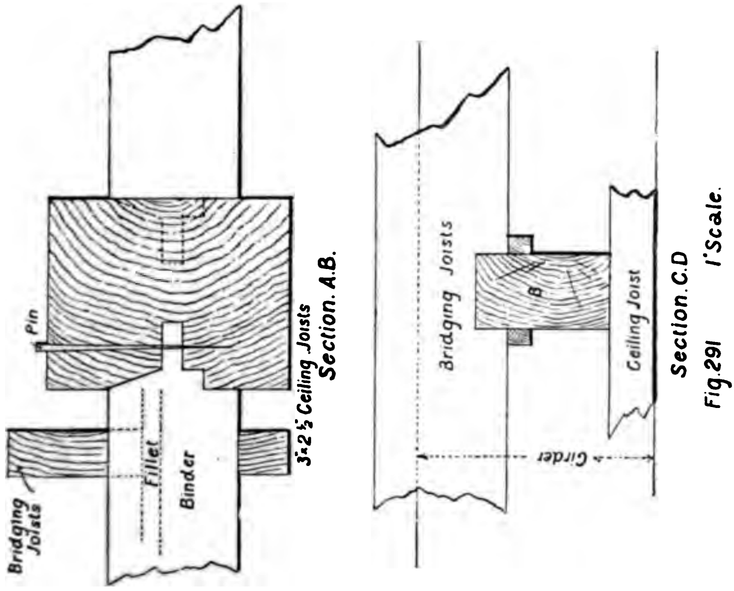
It should be borne in mind that two binders should never be tenoned into the girder at one place, as that would almost cut it in two, and weaken it too much; but they should be placed *hit and miss* fashion as X. (See fig. 290.) The method of jointing is shown in the sections A B, C D.

A better way to secure the binder to the girder, without cutting into the latter, is as fig. 292. An iron stirrup is hung over the girder, with a shoe on each side, to receive the binder. The stirrup is secured to the girder by a bolt at the head.

The girders of framed floors must necessarily be stronger in proportion than binders; and taking 13 inches deep by 11 inches wide—for a 20-feet span—as a basis (by the same rule as that for binders), adding 1 inch in



Plan.
Fig. 290. ⅛" Scale



Section. A.B.

Section. C.D

Fig. 291 1" Scale.

depth and ½ an inch in width for each additional 2 feet in span, we have for—

20	feet span	a girder	13	inches deep by	11	inches wide.
22	,,	,,	14	,,	11½	,,
24	,,	,,	15	,,	12	,,
26	,,	,,	16	,,	12½	,,
28	,,	,,	16	,,	13	,,

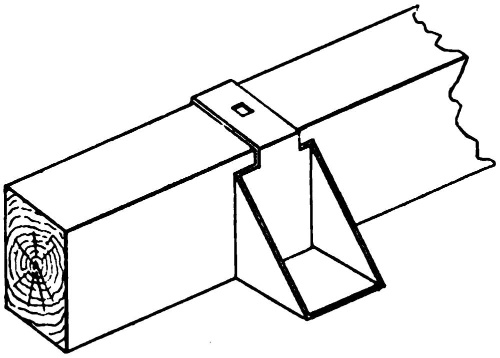


Fig. 292.

Ceiling joists are generally of uniform size—viz., 3½ inches deep by 2¼ inches wide, and are fixed 12 or 13 inches apart; and they should have a bearing, whether on a wall or to a beam, at every 8 feet.

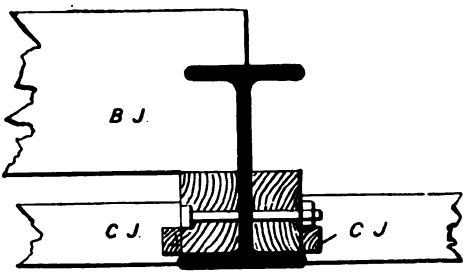


Fig. 293

Iron binders and girders of different sections, in place of wood, are now used, chiefly for double and framed floors; the bridging and ceiling joists being fixed to wood plates bolted to the flanges of the wrought-iron binders, as fig. 293.

In framed floors the binders, with the wood bridging and ceiling joists, are placed between the top and bottom flanges of the girder, and connected with angle irons bolted to the flange of the girder, as fig. 294.

Wooden beams, binders, and girders are often *flitched* to strengthen them—that is, they are cut in half, and reversed with a thin wrought-iron plate between them, as fig. 295, the three being bolted together transversely, as shown in the section.

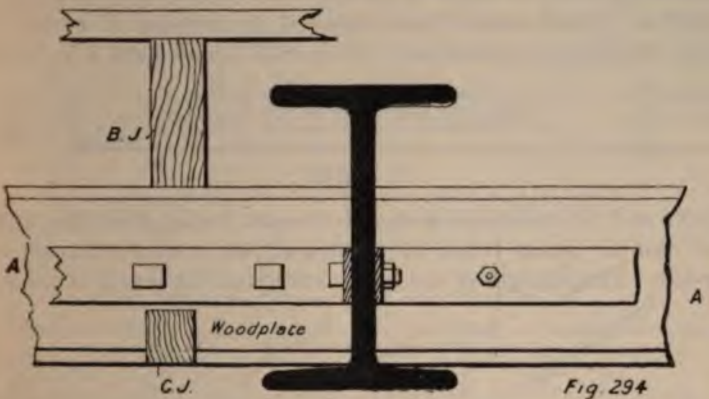
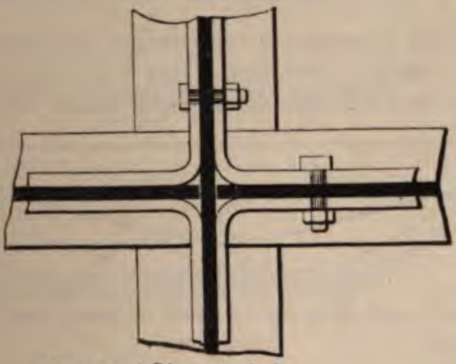


Fig. 294



Sectional Plan at A. A

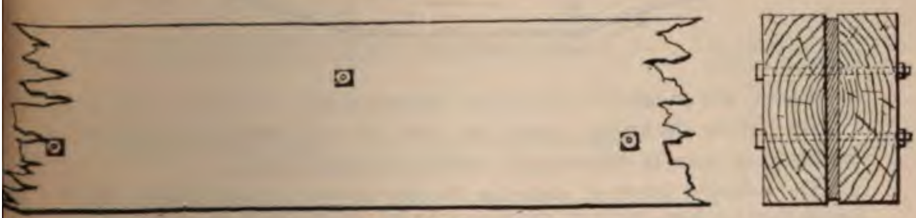


Fig. 295

Or, they are, in exceptional cases, *trussed*, as fig. 296, by a king truss, or by a queen truss, as in fig. 297.

The beam or girder is cut in half, and reversed as the last, but instead of the flitch plate a framed truss, composed of wrought-iron abutments and hardwood struts, is bolted between the two halves, as shown.

Another, though inconvenient, method of trussing is as figs. 298 and 299, which explain themselves, the shoes, Z Z, and stays, Y Y, being of cast iron, and the rods, X X, being of wrought iron to resist the tension. In this case the beam is not cut in two, but the rods go through it, as illustrated. The strength of the truss depends on the length of the struts from the beam, and consequently the stronger it is made the more inconvenient and unsightly it becomes. This is on the same principle as that often seen when thin boards are strengthened to carry flower-pots by strutting underneath, and tying tight a piece of string from each end of the board over the strut.

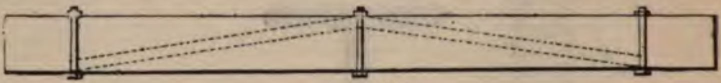


Fig. 296

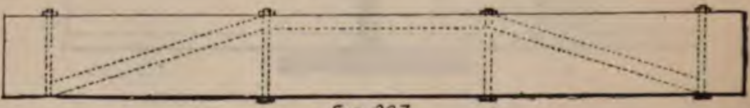


Fig 297

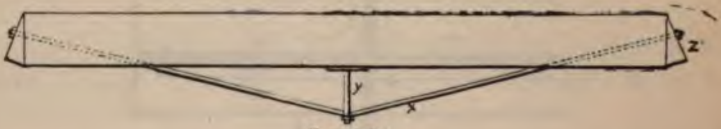


Fig 298

Flooring.—*Flooring* is the covering of the naked framing, and consists of one or other of the many different kinds of floor boards from 1 to 1½ inch in thickness, nailed (on each of their edges) on to each of the bridging joists in either single, double, or framed floors.

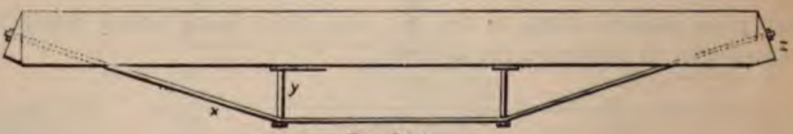


Fig 299

The different kinds of joints for flooring boards (which should always be rebated or grooved so that a greater thickness of floor-board is left on the top side where it will be worn) are as follows:—

Straight or plain jointed (fig. 300), in which the joint of each board is straight and plain.

Grooved and tongued, where one edge of the board has a tongue and the other a groove (fig. 301).

Grooved and tongued with hoop-iron tongues, in which both edges of the board are grooved and an iron tongue inserted, half in each board (fig. 302).

Rebated, with the edge of each board rebated out alternately top and bottom (fig. 303).

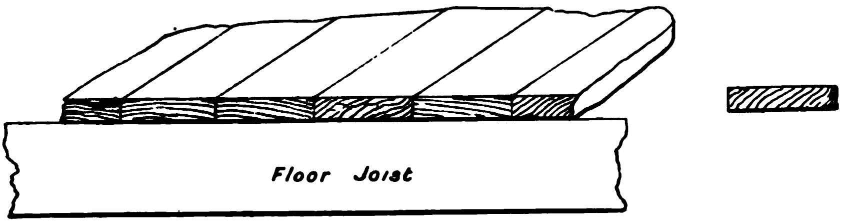


Fig 300

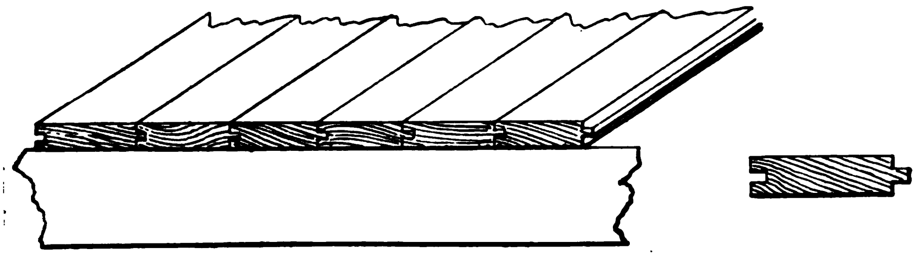


Fig. 301

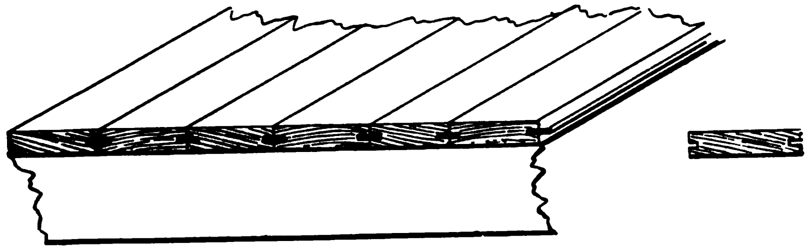


Fig 302.

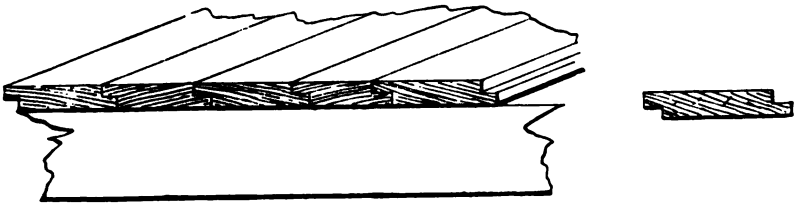


Fig. 303.

Rebated, grooved, and tongued (fig. 304), a combination of figs. 301 and 303.

Rebated and filleted, in which each board is rebated out on one face each side, and a loose fillet is laid on the joists and overlapped by the rebate on each board (*vide* fig. 305).

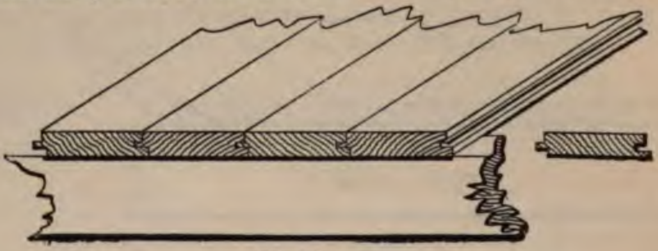


Fig 304

Secret-nailed, by which each board is nailed on the tongue to the joist and covered by the top of the other (grooved) board, which is held down by its (tongued) predecessor (fig. 306).

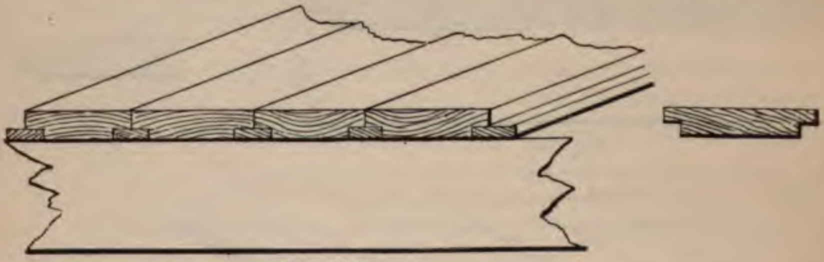


Fig 305

Dowelled, where small oak or other hard-wood dowels are driven into the edge of the fixed board and the other is cramped up to it, so that the dowel enters both boards and keeps them together (fig. 307). They are secretly nailed obliquely between the dowels.

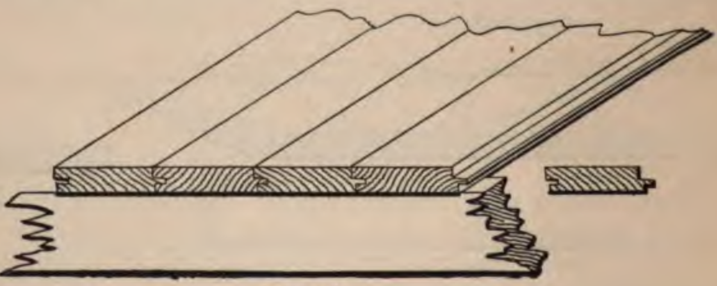


Fig 306

Fillistered are similar to fig. 303, "rebated."

Ploughed and tongued are the same as grooved and tongued (fig. 302).

A new method of secret fixing has lately been invented. It consists

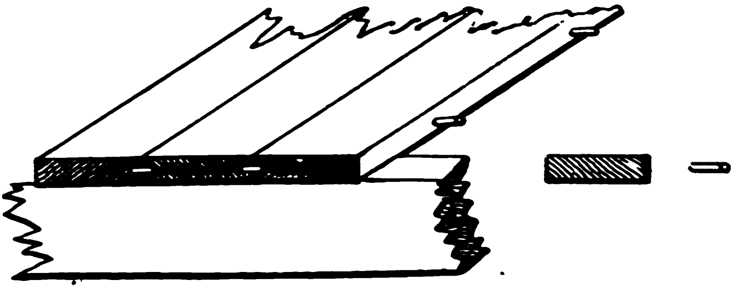


Fig. 307

of shouldered brads, one point of which is driven into the joist by hammering the shoulder, and the board is driven down on to it, as in fig. 308.

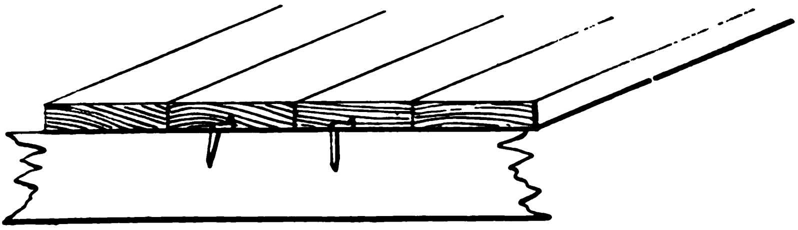


Fig. 308

Headings are the joints of the boards crosswise—*i.e.*, where they are not in sufficient lengths to go the length of the room, and have to be in two or more lengths. They may be either square or bevelled, as figs. 309 and

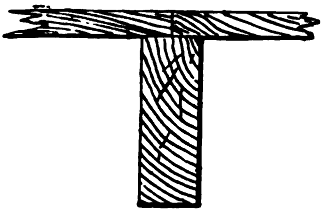


Fig. 309

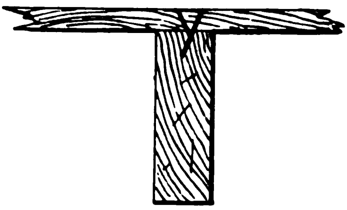


Fig. 310

310, or cross-tongued, as fig. 311, or tongued, as fig. 312, or rebated and tongued, as fig. 313.

Floor boards are usually laid in "uniform" thicknesses of from 1 to 1½ inches, and in from 3½ inch to "batten" or 7-inch widths. They should, under any circumstances, have their edges shot—*i.e.*, truly planed, so that they can be "dogged" or "cramped" up tight to each other before being nailed; or they are laid folding in common work, as fig. 314.

In good work the nails should be punched below the general surface of the floor, the boards planed off to one level, and the nail-holes stopped up with putty, before a floor can be said to be complete.

Double floors may sometimes mean that the flooring or floor-boards are laid on the joists in two thicknesses, generally ¾, or ⅞, and 1 inch thickness, the bottom thickness being straight-jointed, and often laid diagonally across the joists; while the other—either grooved and tongued, or of some other special section—is laid on in the ordinary way above the *sub-floor*, as the bottom one is called.

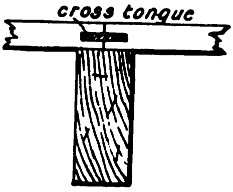


Fig. 311.

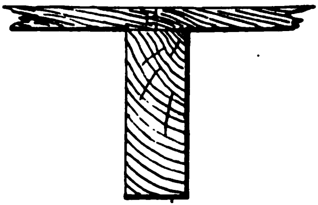


Fig. 312.

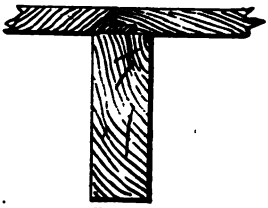


Fig. 313.

The various kinds of floors having been explained to the student, it only remains to say that the principle of wooden beams and girders is antiquated, bad from its elaborate framings, risks to fire, and the sagging and uncertainty of the large-sized members. It has been superseded by iron or steel for binders and girders, the latter being considerably superior in forming a rigid mass, its comparative impunity from fire, etc., but care should always be taken to leave a space between the floor-boards and top of the iron or steel joists for gaspipes, etc.

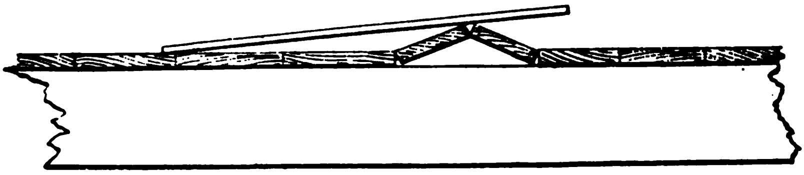


Fig. 314.

CHAPTER IX.

PARTITIONS.

Partitions Defined—Framed or Quartered Partitions—Trussed Partitions.

Partitions Defined.—A partition[*] is a skeleton wood framing, used instead of a wall to divide one room from another. It is only suitable for use above the ground-floor, so as to be free from the effects of damp. The principal advantages which partitions possess are, that they save space, and being light in weight, can be raised upon a floor; whereas a brick partition wall must either rest on another wall beneath, or be built on girders, which entail additional expense. Against these advantages must be set off the facts that partitions are inflammable, conductors of sound, and very apt to prove a harbour for vermin.

There are really two kinds of partitions—the ordinary *framed* or common *quartered* partition, and the *trussed* partition. Before proceeding to explain and illustrate each one separately, it will be advisable to make a few remarks on partitions generally.

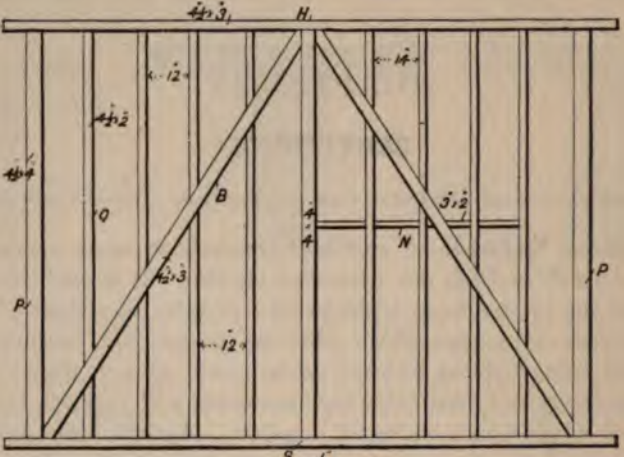
The general rule is to build up partitions resting upon the floors, which is in itself bad construction, because as soon as the floor sags or moves the partition goes with it, causing the plaster cornices to crack and come away from the ceiling above, unless that is connected to the partition itself, instead of underneath the joists of the floor above, which should run from wall to wall independently of and parallel to the partition itself; or the continual additional weight of the partition on this floor causes the part immediately underneath the partition to sag more than the other part of the floor, which results in the cracking of the ceiling below.

A better plan is to hang the partition either from the floor above or from the roof. These are made purposely stronger than otherwise needed, in order to carry the additional weight, and render the partition tolerably rigid; but the best and proper way is to build the head and sill of the partition into the main walls wherever practicable, so that if the one goes the other goes with it; and, in addition, to brace them towards the walls or bearings, so that any weight that comes on the head of the partition is thrown, by means of these braces, on the walls.

---

[*] Called in the North of England a *stoothing*.

Partitions may be lathed and plastered on each side; but sometimes they are *bricknogged* in addition—*i.e.*, the spaces between the quarterings are spaced out to suit the bricks, and being 4½ inches thick, are filled in with brickwork; or otherwise in thinner partitions the bricks are laid on edge.



¼ Scale
Fig. 315.

In other cases the partitions are temporarily boarded up on each side, and the interstices filled up with concrete, generally composed of breeze and cement. Sometimes, however, the outsides of the partition are covered with inodorous felt, and the spaces filled with sawdust, before the plastering is done.

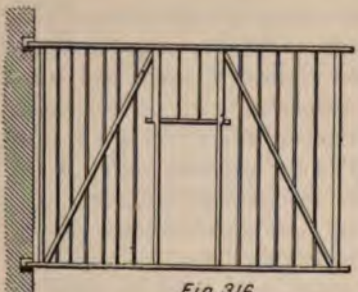


Fig. 316
⅛ Scale

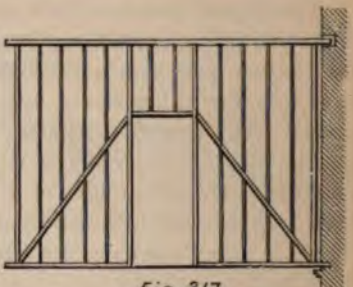


Fig. 317
⅛ Scale

Framed or Quartered Partitions.—An ordinary *framed* or *quartered* partition consists of head H, sill S, posts P, studs or quarters Q, and nogging pieces N, and generally, though not always, braces B (see fig. 315).

The partition is 4½ inches thick, the head and sill 4½ × 3 inches, posts 4½ × 4 inches, studs 4½ × 2 inches, braces 4½ × 3 inches, and nogging or stemming pieces 3 × 2 inches.

If a doorway is required in the partition it is framed either as fig. 316 or as fig. 317.

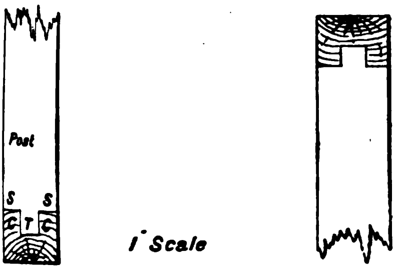


Fig 318

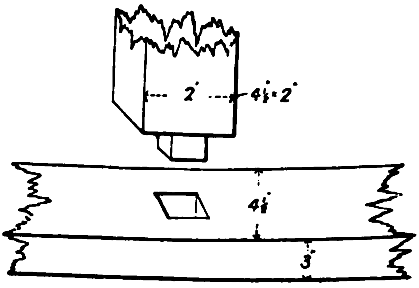


Fig 319

The joints used in framed partitions of the ordinary kind are very simple, and as follows:—

The joint at head or sill with the posts, being an ordinary mortise and tenon, as in fig. 318; S S being the shoulders, T the tenon, and C C the cheeks. The tenon—as, in fact, all tenons should be, as a rule—is in width one-third of the thickness of the stuff, so that it has no less than one-third (or its width) on each side of the mortise.

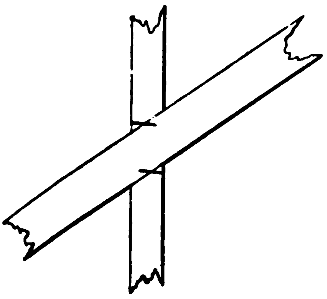


Fig 320

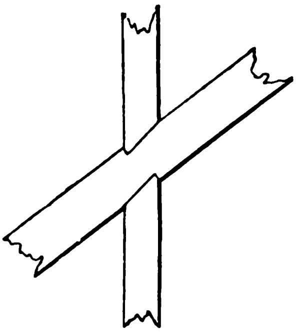


Fig 321.

A *stub* tenon is the name given to the joint between studs and sill or head, the tenon only being for the purpose of keeping it in position, and going into the mortise about one inch (fig. 319).

The joint between studs and brace should be as fig. 321, but it is usually as fig. 320.

The junction of the brace, post, and sill is very simple, being as fig. 322. But where the brace is framed into a doorpost (as fig. 317) it is done as fig. 323.

The joist between doorhead and post, where the brace does not spring from it, as fig. 324, is similar to the *tusk-tenon* between trimmer and trimming joist.

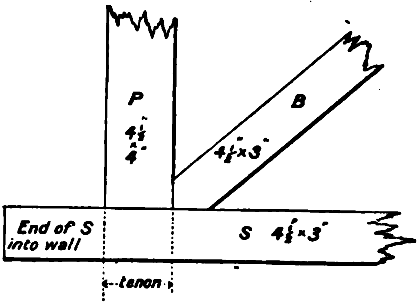


Fig 322

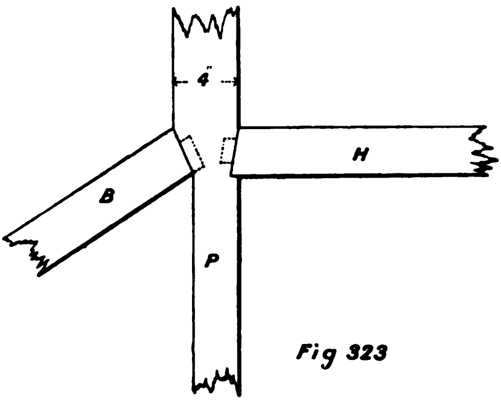
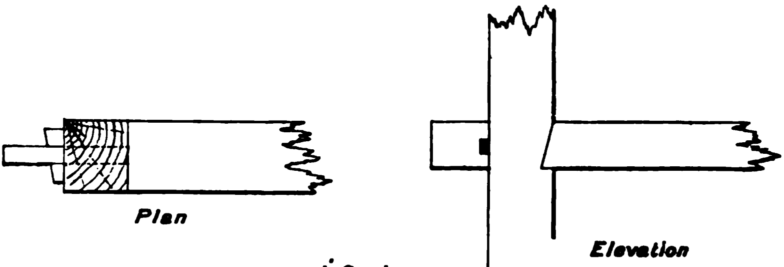


Fig 323



1" Scale

Fig 324

Where partitions have to be built on floors, and cannot rest on stouter joists (as fig. 325), they are supported by bearers framed between two joists (as fig. 326), about 4 feet apart.

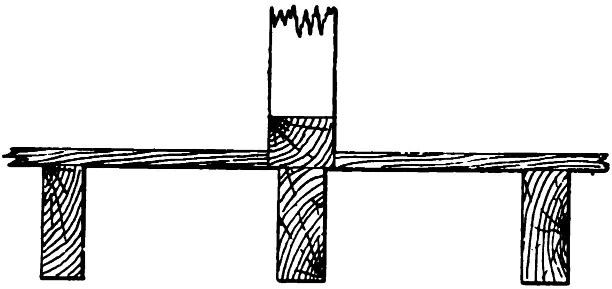
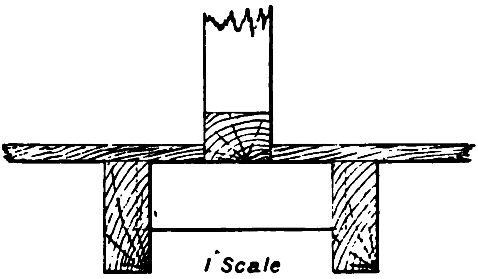


Fig 325 1" Scale

Sometimes they rest only on the floor-boards, as fig. 327.

It should be borne in mind that the studs are fixed from 12 to 14 inches apart, or from 14 to 16 inches centre to centre, on the same principle as joists, ceiling joists, rafters, and other bearing timbers.



1" Scale

Fig 326

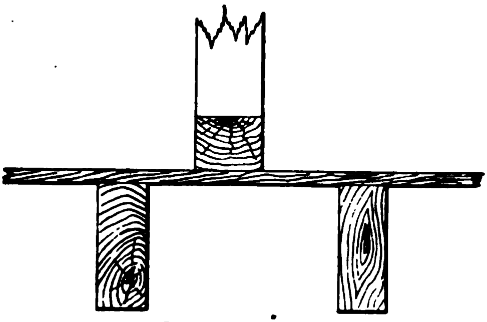


Fig 327. 1" Scale

Trussed Partitions.—*Trussed* partitions are those which have to carry a floor above, or they have some other work to do, requiring more than the ordinary strength of "framed" partitions. They are similar to roof trusses in construction, but oblong instead of rectangular, and of two kinds—*king-post*, as fig. 328, to suit side doors; or *queen-post*, as fig. 329, where the doorway comes in the centre.

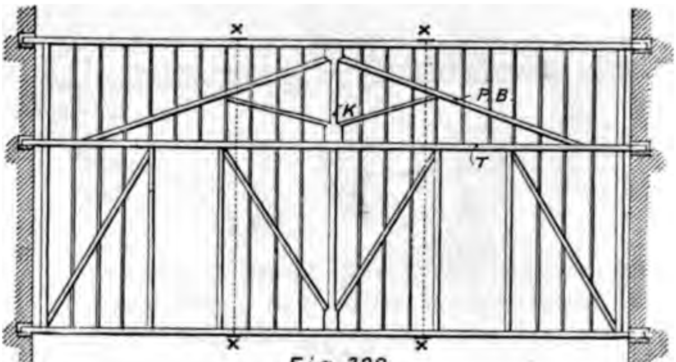


Fig 328

They are really framed trusses, filled in afterwards with studding or quarters.

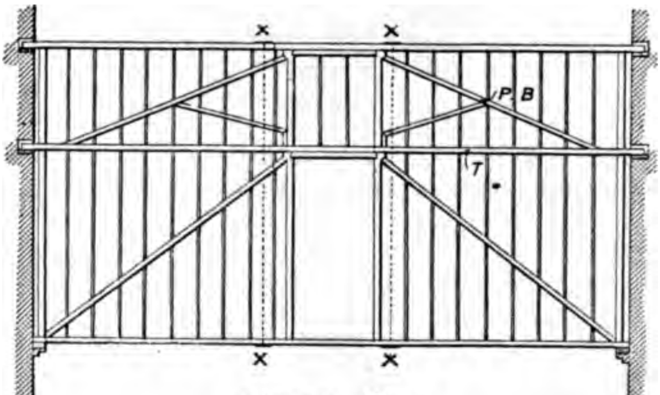


Fig 329. ⅛" Scale

The joints employed other than those used in the ordinary partition as explained, are those of the principal members of the truss, as between principal back, and intertie, T, in both trusses, which is done as fig. 330;

King and principal back, etc., as fig. 331.

The queen-post, etc., joint should be as fig. 332.

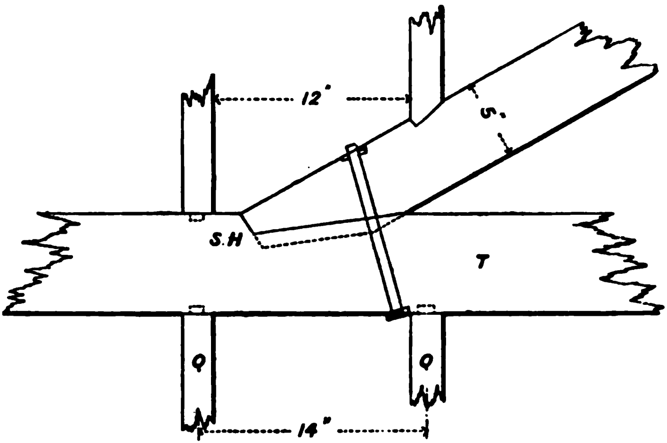


Fig 330

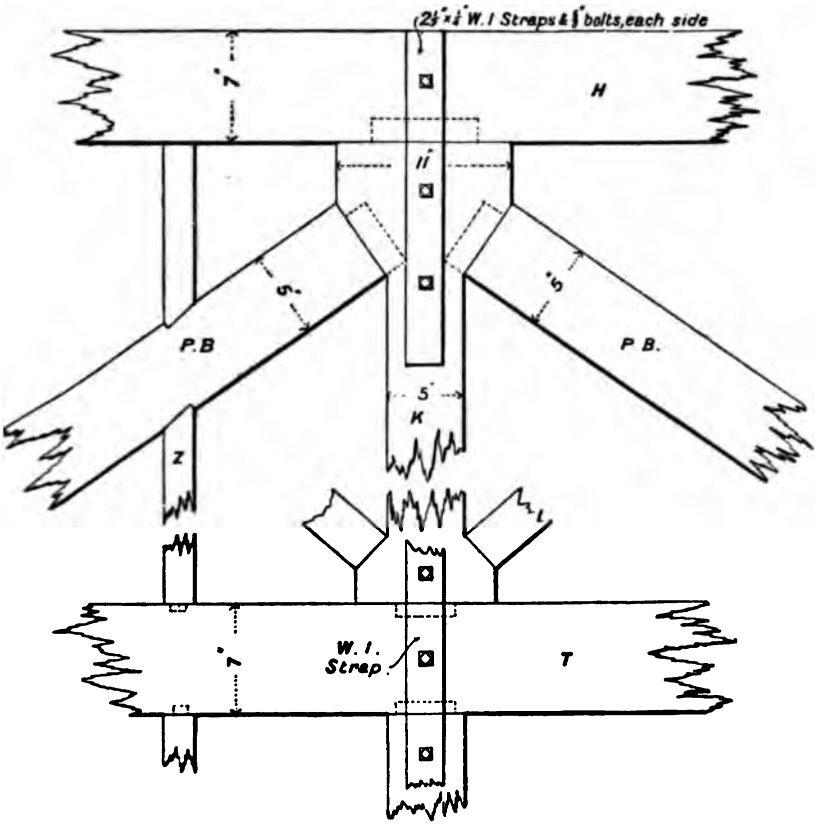


Fig 331.

It is as well to bolt the head and sill of the complete truss together i one or more suitable places, as X X, figs. 328 and 329, when possibl

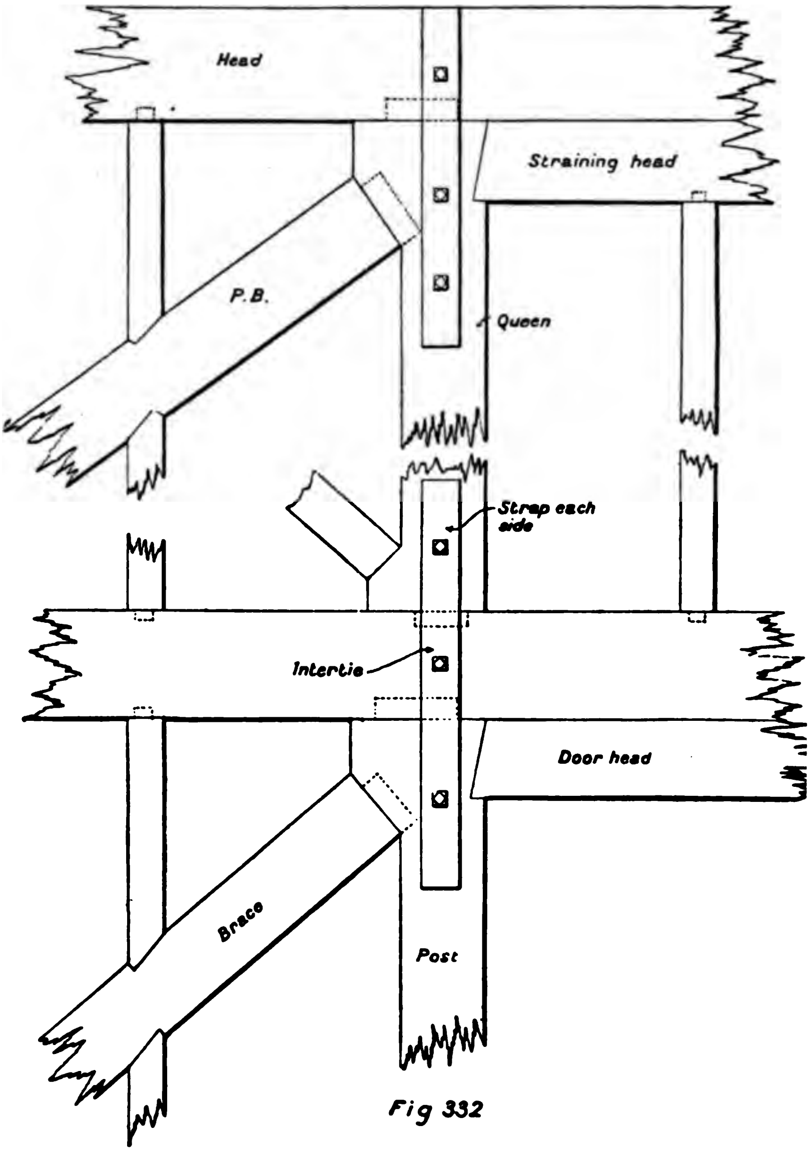


Fig 332

in order to make the partition one complete framing, though made up c different parts.

All braces, where practicable, should incline (or abut) at an angle of about forty degrees.

Partitions of ordinary span, and carrying only their own weight, are generally understood to be 4½ inches thick; but, wherever they are of greater span, they should be, say, 1 inch thicker for every 10 feet; and, of course, where they have to carry floors or roofs, they must be of special thickness to meet the requirements, and, moreover, must be trussed in one way or other, as the circumstances will allow—either between head and sill or between intertie and head. The latter is the usual way, owing to the presence of doors and other openings, which take up so much of the height of a partition.

CHAPTER X.

ROOFS.

Local Adaptation of Roofs—Couple Roof—Couple-close Roof—Fished Joints—Scarfs—King-post Roofs—Queen-post Roofs—Wood and Iron King-trusses—Wood and Iron Collar-truss—Queen Flat-truss—Mansard Roof—Details of Roofs.

Local Adaptation of Roofs.—A roof is a framing which covers the top of the whole building, as a protection against the elements. In different countries, having different climates, and being subject to different kinds of weather, it is of course necessary that the roofs of buildings should be designed and constructed so as to meet those variations of climate. For instance, the northern countries of the world have steep-pitched roofs, to throw off the snow and prevent the water from sucking-up between the laps of the different materials used as a covering; while in hot countries, where there is little, and that very heavy rain, the roofs are constructed on the flat. Therefore the framing of wood-roofs must be suited to the weight requirements of the covering which it has to carry, according to the climate.

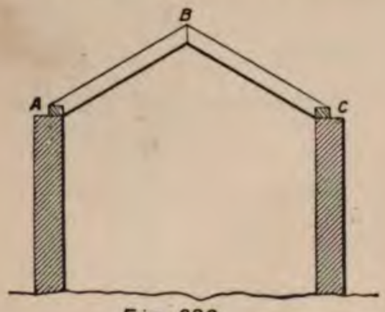


Fig 333

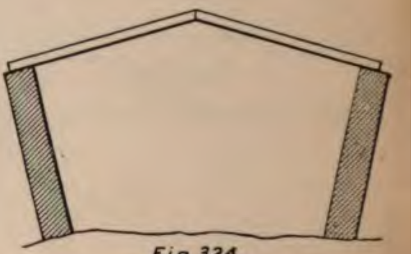


Fig 334

Lead, zinc, copper, stone, or asphalte coverings are generally laid on flat roofs; slates on pitches of about 30 degrees from the horizon; and tiles or wood-shingles on a 45-degrees pitch.

Before proceeding to deal with each roof separately on its own merits it may not be out of place to give the student an idea of the origin of the different kinds.

The first and simplest form of a roof is as fig. 333, from which, supposing the rafters are, as it were, hinged at A, B, and C, it may be imagined that as soon as the weight on the rafters exceeds a certain maximum, the walls will be pushed out by the extra weight or thrust brought down on them by the rafters (see fig. 334).

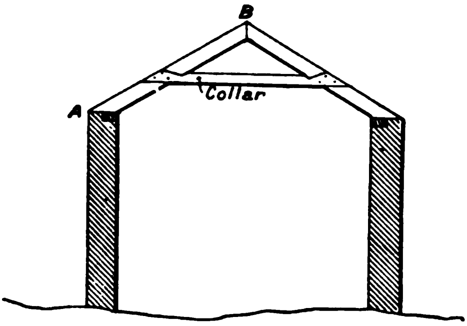


Fig 335

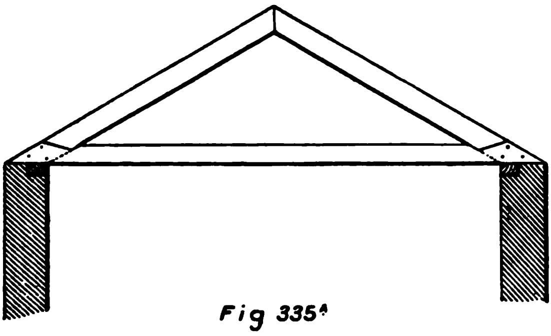


Fig 335^A

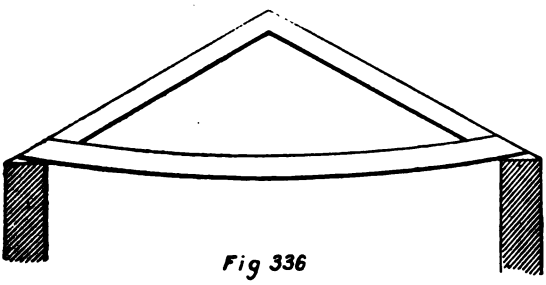


Fig 336

To obviate this, the collar first, and afterwards the "tie," were added as a means of tying in the rafters: first, by the collar fixed part of the way between the wall-plate and ridge, A and B, as fig. 335; and then, as the length of the span and rafters increased, it was found necessary to tie in the feet of them, as fig. 335, by means of the tie-beam.

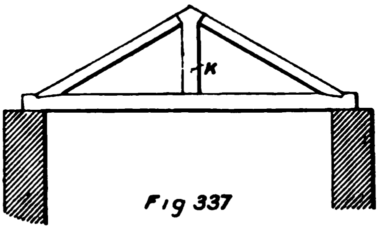


Fig 337

The next difficulty encountered, as the spans were increased, and consequently the length of the tie-beams, was that the tie-beam was apt to sag in the middle from its own weight over such long bearings (see fig. 336);

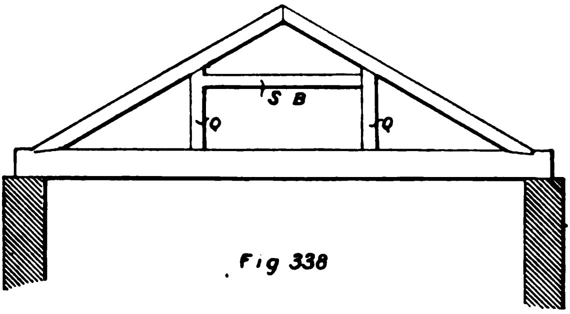


Fig 338

to counteract which the king-post in shorter spans, and two queens in longer spans, were put in to sling up, as it were, the tie-beam to the ridge or apex of the rafters in the one case, and to the straining beam—which did duty for two apexes—in the other, as figs. 337 and 338.

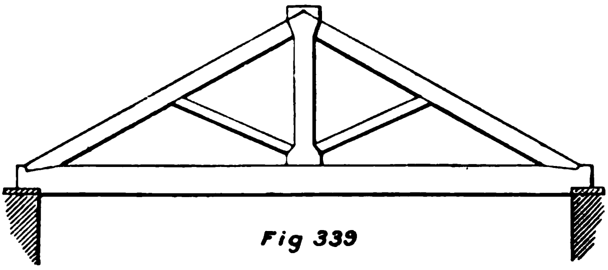


Fig 339

The last defect to be remedied was the sagging of the rafters between the wall-plate and apex; and this was done by means of struts, S S, so named because they "strut" up the rafter from the king-post or queen, as the case may be (*vide* fig. 339).

The above description will explain the origin of the different members of the ordinary truss; and as spans and trusses increase, and their consequent defects arise, so indefinite additional ties and struts are added to the frame to counteract them.

Some kinds of roof-trusses are a combination of wood and iron, the rafters and struts generally being of wood, and the suspenders and ties either of iron or wood, according to circumstances.

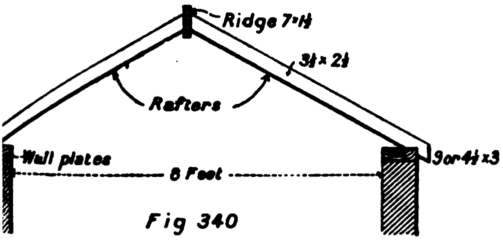


Fig 340

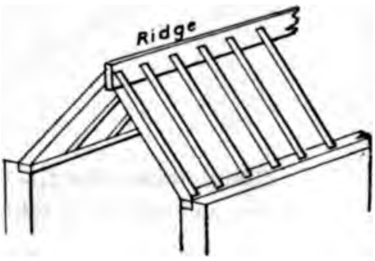


Fig 341

Couple Roof.—The couple roof—the simplest of the whole series—consists of the following parts—viz., wall-plates, bedded on the walls, and running longitudinally; and two rafters, raised from each wall-plate to the pitch required from the wall-plate line as horizon. At the apex or meeting-place of these two rafters the ridge is fixed, running longitudinally, and generally parallel to the wall-plates or walls (*vide* figs. 340 and 341).

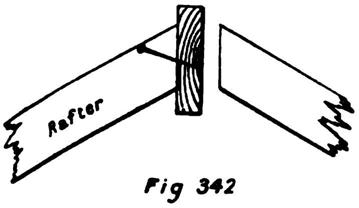


Fig 342

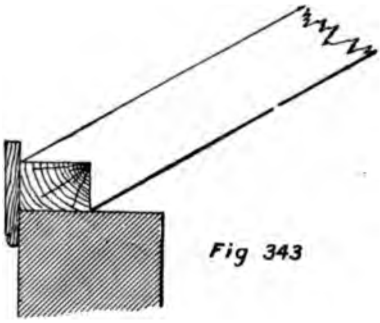


Fig 343

This form of roof is only suitable for spans under 10 or 11 feet, the rafters being spaced 12 inches apart, and usually 3½ inches × 2½ inches in section. The ridge is generally 7 inches × 1½ inches, and the wall-plates 3 inches deep and either 4½ inches or 9 inches wide, on bed, according to circumstances.

The joints required in its construction are very simple, and can all be made by the use of the saw; that at the ridge being as fig. 342, and that at the junction of the foot of the rafter and wall-plate being as fig. 343 or fig. 344; the former being used where there is an outside eaves-gutter, and the latter where there is a lead gutter between two roofs meeting at the wall-plate from opposite directions. Fig. 345 shows the mode of connecting the rafters and wall-plates for overhanging eaves.

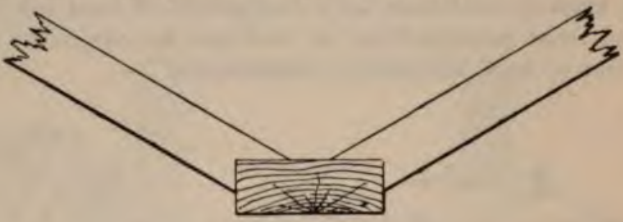


Fig 344

Couple-close Roof.—The "couple-close roof" is a step higher than the last, and consists of rafters, ridge, and wall-plates, with the addition of a tie fixed to the foot of each rafter, which often does duty for a ceiling joist (see fig. 346).

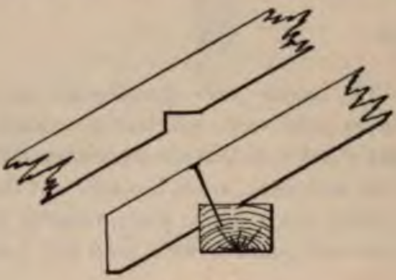


Fig 345

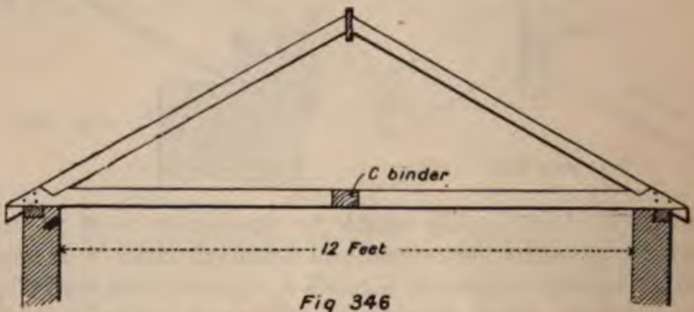


Fig 346

These roofs are suitable for spans up to 12 or 14 feet; but after they exceed the 10 feet it is necessary that the rafters should be made 4½ inches × 2¼ inches. The tie is usually the same size as the rafter, and the joint between them called a *dove-tailed halving*, as fig. 347, half the thickness being cut off both rafter and tie to a dove-tail pattern, which, when in position, prevents one pulling away from the other.

Collar Roof.—It must be always borne in mind that rafters must have a support at intervals of every 8 feet, or they will sag; and if the space between ridge and plate exceeds 8 feet, additional support, in the form of a purlin or collar, must be placed between them (*vide* fig. 348).

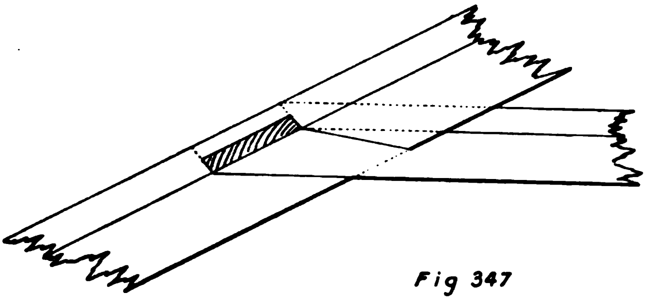
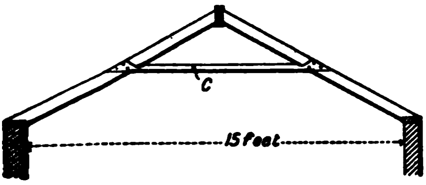


Fig 347

This leads us to the "collar" roof, suitable for spans up to 16 or 17 feet, and designed to meet the requirements just alluded to. It has also the advantage of giving more height to the ceilings of the rooms, etc., immediately under the roof, where a tie, as in the "couple-close" roof, would be too low and in the way.



⅛ Scale
Fig 348

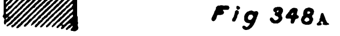


Fig 348A

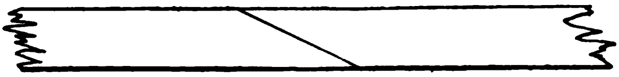


Fig 348B

The joints in this form of roof are precisely similar to those last named; but the roof itself, as a whole, is considerably inferior in construction, because, there being no tie at the foot of the rafters, the weight of the roof is apt to cause them to spread, pushing the walls out, and lowering parts of the roof in consequence. The rafters and collars are

4½ inches by 2½ inches in section, and spaced 12 inches apart, or 14 to 15 inches centre to centre, as in all other framings; but these collars are not always used to each rafter, one being framed to every sixth or seventh rafter, and a *purlin*—a longitudinal beam running parallel between plate and ridge—being placed between collar and rafter (as fig. 348 A), and supporting the rafters between each of its bearings on the framed collars.

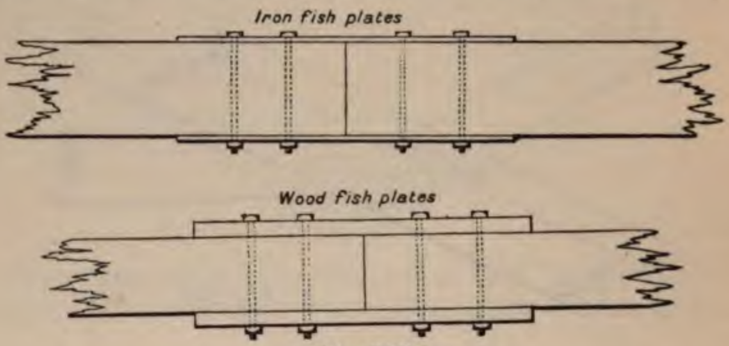


Fig 349

The purlins and ridge are jointed in their length by bevelling, fished joints, or scarfs to resist tension and bearing, the particular strain to which they are subject.

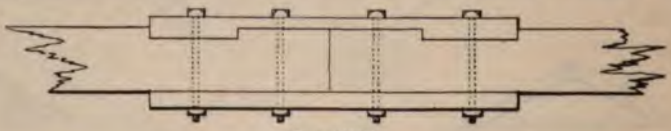


Fig 350

The "bevelled" joint (fig. 348 B) is the simplest in work and most common in use, though for obvious reasons it can only be employed over bearings on walls or trusses.

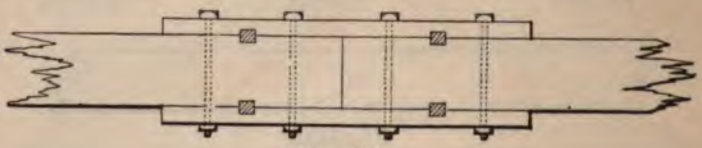


Fig 351

Fished Joints.—*Fished* joints are not often used, on account of their awkwardness, and their weakness in comparison with the expense which they entail. They are, practically speaking, "butt" joints, whereof the ends are kept in position by fish-plates of wood or iron, fastened generally to each side of the beams, and connected together by through bolts (fig. 349).

The bolts should be placed "hit-and-miss" fashion, so that plates and beams are only cut once in the length of their fibres. This form of joint, when in tension, causes all the strain to be thrown on the bolts; and as these often become loosened by the shrinkage of the timbers, they then press and crush the fibres, which results in the yielding of the joints.

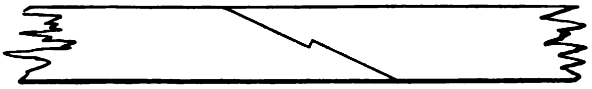


Fig 352

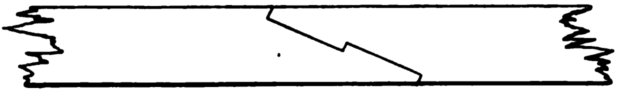


Fig 353

To obviate this as much as possible, the joints are *tabled* in both iron and wood alike, as fig. 350; or *keyed*, as fig. 351. Each of these methods, while conferring a benefit, also creates another defect, by decreasing the section and consequent strength of the timbers themselves.

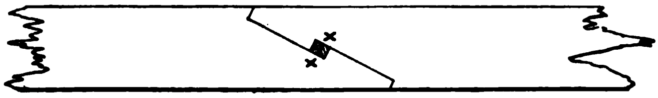


Fig 354

These forms of joints are also suitable for lengthening posts and other upright timbers subject to compression; but, for such purposes, it is better that they should be fished on all sides, to prevent any movement laterally.

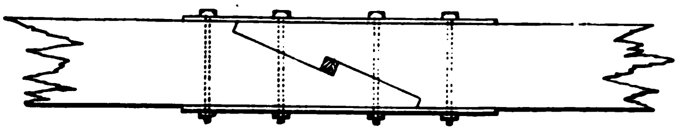


Fig 355

Scarfs.—"Scarfs," as used in joints, to lengthen purlins and ridges—*i.e.*, to resist tension—are, as a rule, made as fig. 352; or fig. 353, which is slightly more intricate; though fig. 354 is still better, as it can be tightened up by means of the wedges or keys, X.

Still, this is not really complete without the fish-plates, to allow the tightening to be done properly, as fig. 355, which may be said to be the best scarf to resist tension.

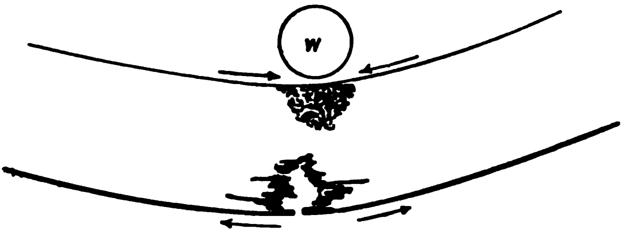


Fig 356

While dealing with "scarfs"—though a little out of place—it may be as well to explain, so that the difference can be noted, those that are designed to resist compression used in perpendiculars, posts, etc.,

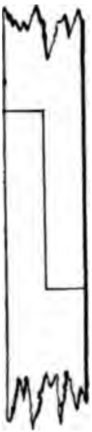


Fig 357

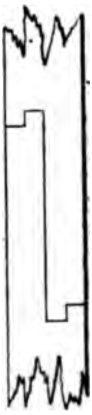


Fig 358

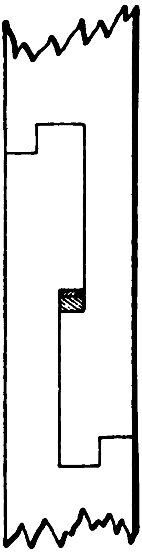


Fig 359

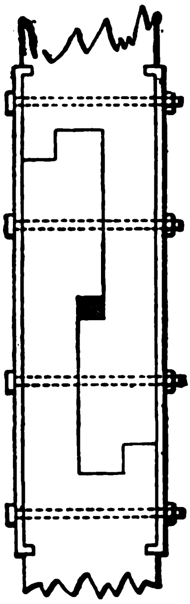


Fig 360

and that used for bearing timbers subject to cross strain, where the top fibres are in compression and the bottom in tension, as fig. 356.

The principle of scarfs for tension is a keyed *bevel*, while that for compression is a keyed *butt* joint, as square as possible, so as to distribute the weight all over its area.

Fig. 357 represents the simplest form of scarf used in posts, though this may be improved by checking, as fig. 358; and still more by wedging or keying, as fig. 359; and, further still, by fish-plates and a little tabling, whether in iron or wood, as fig. 360.

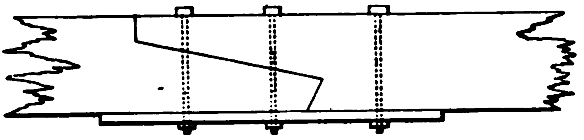


Fig 361

The joint to resist cross strain, applicable to breastsummers, girders, binders, joists, and other bearing timbers, is as fig. 361; the square butt joint, X, resisting the compression in the top fibres, while the oblique butt and the fish-plate and bolts resist the tension on the bottom fibres.

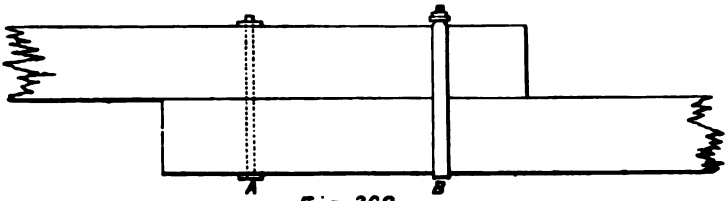


Fig 362

Before leaving the subject of joints in longitudinal and other bearing timbers we must not forget the *lapped* joint, though it is the least workmanlike of joints, and rarely used except in rough work. It consists in lapping one length of timber over the other, as fig. 362, and securing them together either by means of bolts, A, or straps, B.

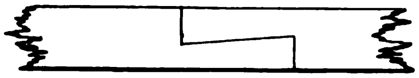


Fig 363

Wall plates are scarfed, as in fig. 363, though they may be bolted together in addition.

King-post Roofs.—The "king-post" is the next roof which circumstances, as it were, bring before the carpenter, and to his help into the bargain, as has been explained earlier in the course of these notes.

This form of roof is practically the beginning of all "trusses," which are complete framings in themselves, spanning from wall to wall, and doing duty for the cross walls, in that they support, in their turn, the ridge and purlins, which require a bearing every 8 or 10 feet. Trusses should be no more than 8 or 9 feet apart, and have a 9-inch bearing on each wall.

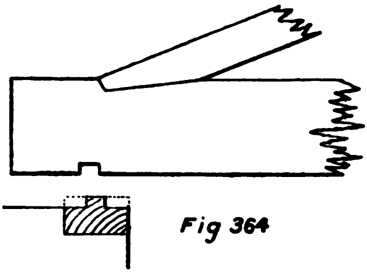


Fig 364

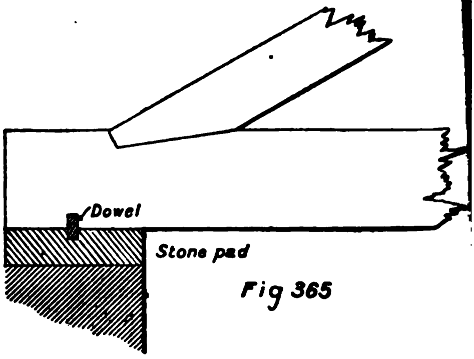


Fig 365

The tie-beams of trusses are generally *cogged* on to wall-plates, or wood-templates about 30 inches long, built in the walls, as fig. 364; or, another method is to dowel them on to stone pads, as fig. 365.

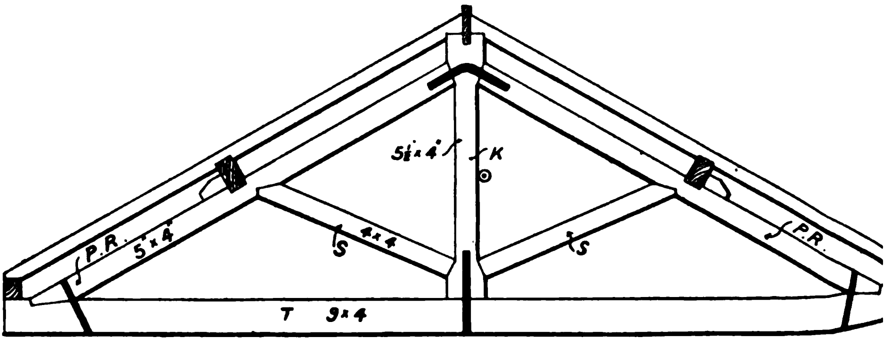


Fig 366 ½" Scale

Fig. 366 represents a king-post roof-truss. P R is the principal rafter, 5 inches deep and 4 inches thick; T the tie-beam, 9 × 4 inches; S the struts, 4 × 4 inches; and the king-post, K, is 5½ × 4 inches at X; but, as it has to be cut out to give a bearing for the struts and principal rafter, it really comes out of 9 × 4 inch stuff, being 9 inches wide both at top and bottom, reduced between to 5½ inches, as shown.

A very simple way to familiarity with and recollection of the safe sizes of the various members of a king-post roof is as follows: Divide the span by 5, and call the quotient inches, which is the required thickness; the struts should be always square, and middle of the king-post a little wider than its thickness; and the setting out of the bevels will then give the actual size of the stuff from which it is to be cut. Assuming 9 inches and 5 inches as the standard depths for tie-beams and principal rafters for 20 feet span respectively, add 1 inch to each for every 5 feet additional span. Should the dividing process give the answer with a half-inch, it is usual to take it off for slated roofs, which incline at an angle of from 26 to 30 degrees, or about "one quarter pitch" —that is to say, the ridge is a quarter of the span in height above the tie-beam; but for tiled roofs add 1 inch for the odd parts, as tiled roofs have more weight to carry, and they are usually inclined at an angle of 45 degrees, being what are called "half-pitched" roofs.

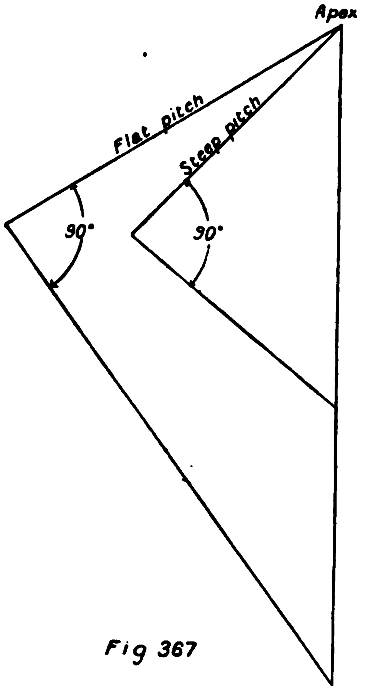


Fig 367

Flat-pitched roofs are not so strong as those that are pitched higher. The nearer to the perpendicular that wood is fixed the stronger it is. This is shown by the fact that the horizontal thrust of a pair of rafters is proportionate to the length of the oblique line drawn, at right angles from the foot of the rafters, to the perpendicular dropped from the apex. See fig. 367, where it will be seen that the flatter the roof is the longer the oblique line.

The joints of a king-post truss, in fact, all consist of mortises and tenons entering but a short distance into the timbers; and they have all bevelled shoulders, which ought, wherever possible, to be at right angles to the incline of the roof.

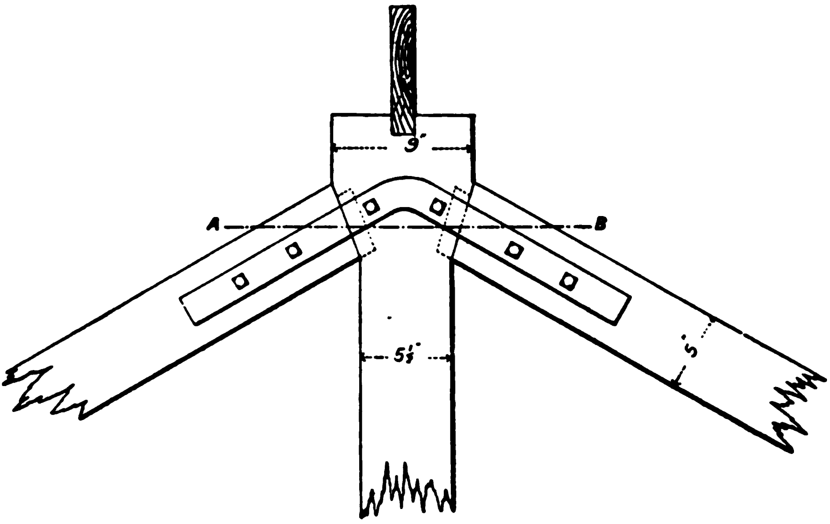
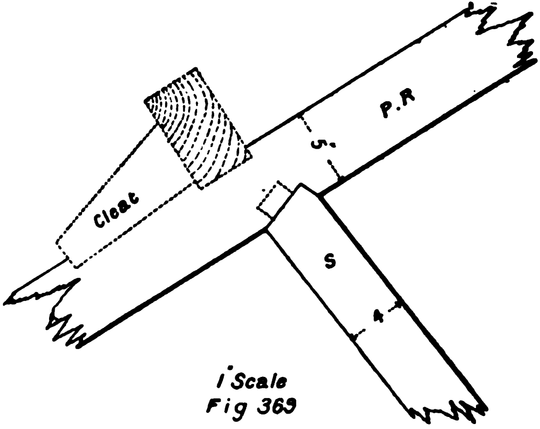


Fig 368. 1" Scale



1" Scale
Fig 369

Fig. 368 is the joint between king-post and principal rafters at the apex supporting the ridge, a pair of 2½ × ⅜ inch wrought-iron straps, bolted from side to side, completing the joint; or in practice a through-bolt from A to B will answer the same purpose, though not so good.

Fig. 369 explains the joint between the strut and principal rafter carrying the purlin. This requires no ironwork.

Fig. 370 is an elevation, and fig. 371 a section, of the joint between king-post, tie-beam, and struts, which should explain itself.

The truss is either tightened up to what is called a "camber" by means of the stirrup-strap, with the gibs and keys or cotters, as shown, or by a bolt which goes up through the centre of the tie-beam into the king-post, where a nut is let in through a hole to tighten it up.

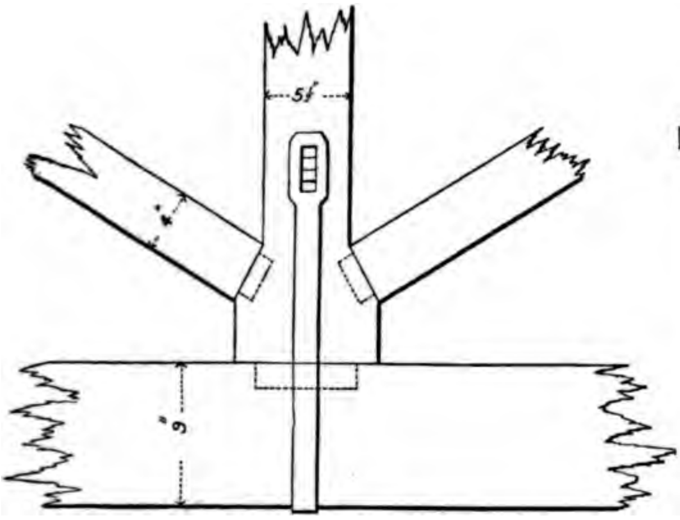
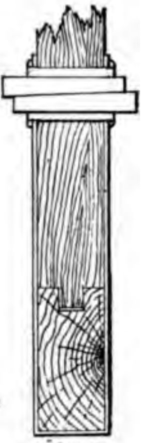


Fig 370 1" Scale



1 Scale
Fig 371

The *camber* is the rise (about ½ an inch in every 10 feet) given to the centre of the tie-beam; so that when the roof settles, the tie-beam may stay at its level, instead of dropping below it (*vide* respectively figs. 372 and 373).

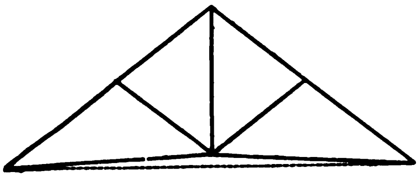


Fig. 372.

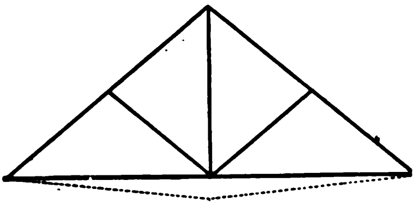


Fig. 373.

The joint between the tie-beam and the foot of the principal rafter is called a *butting* joint, being as fig. 374; which is completed either by a 2½ × ⅝ inch wrought-iron heel-strap encircling the joint, as shown, or by a bolt put obliquely through the centre of the tie-beam and rafter. The mortise and tenon are similar to fig. 375. Instead of this "butting" joint, a *bridle* joint is sometimes used (see fig. 376), which will show that bridle joints are really the converse of the butting joint or a mortise and tenon, when applied to other framing.

They are not very often used, though they are another form of joint.

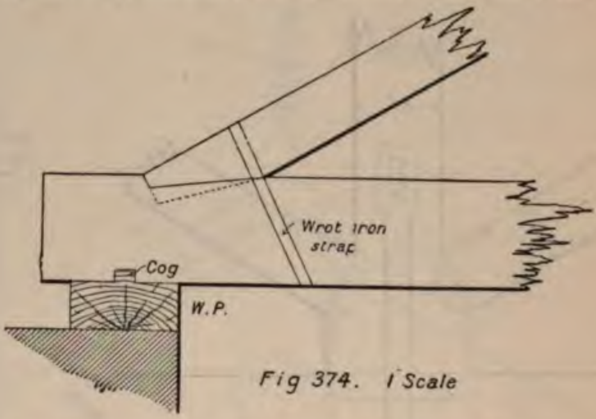


Fig 374. 1" Scale

The bridle should never be more than one-fifth of the thickness of the timber, on account of the weakening of the cheeks, which would be very liable to be wrenched off if they were not considerably more than the bridle in thickness.

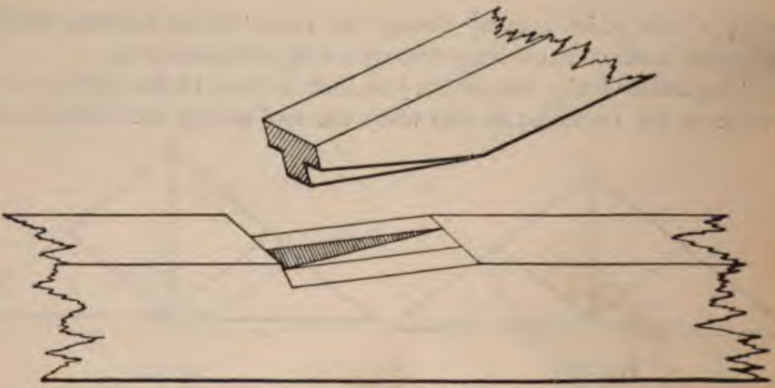


Fig 375

Sometimes king-post roof-trusses are constructed with the tie-beam in two thicknesses, one notched to each side of the foot of the principal rafters and king-post, as in fig. 377.

The other joints are the same as in the ordinary truss, with the exception that the ridge is boxed lower down into the king, so that the top of the common rafters is level with the top of the principal rafters (fig. 378).

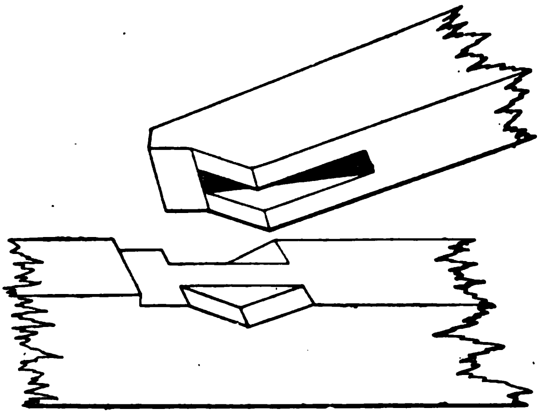


Fig 376

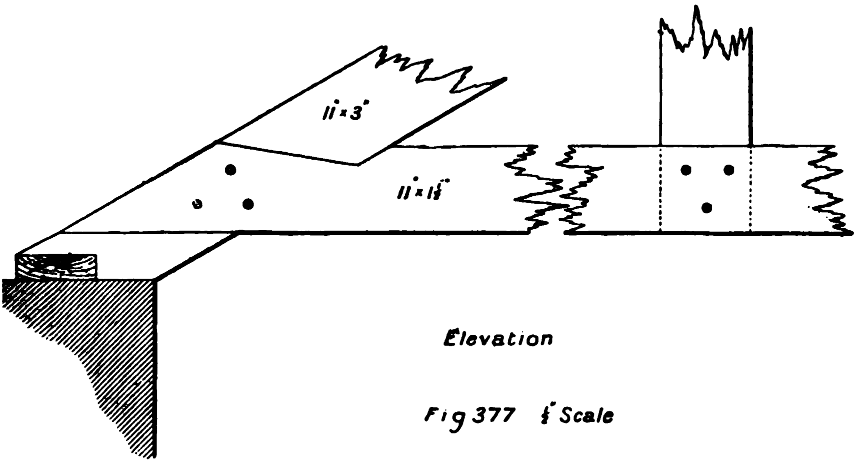


Fig 377 ½" Scale

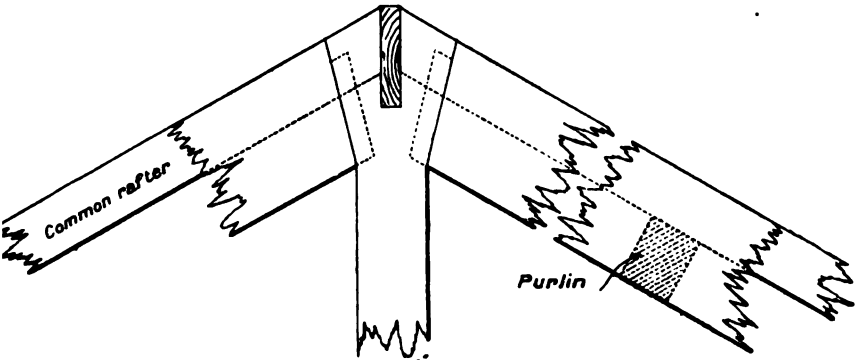


Fig 378 ½" Scale

This, of course, necessitates the purlins being framed into the principal backs, which is done by means of a tusk tenon (*vide ante*, fig. 281).

King-post trusses are suitable for spans up to 30 feet.

Queen-post Roofs.—*Queen-post trusses* are used for spans over 30 feet, and contain two perpendiculars to brace up the tie-beam spanning the walls.

Fig. 379 is a "queen-post truss" for a 32-feet span. The same form is suitable up to about 42 feet span, and beyond that size *princesses*, or intermediate posts and struts, have to be inserted between the "queens" and the heels of the roof, as shown by dotted lines; and it is sometimes necessary to frame a small king-post truss (also shown on the figure by dotted lines) above the straining beam St, to support the ridge. S S is the straining sill, and Q the queens. The other members are known by the same names as in other trusses.

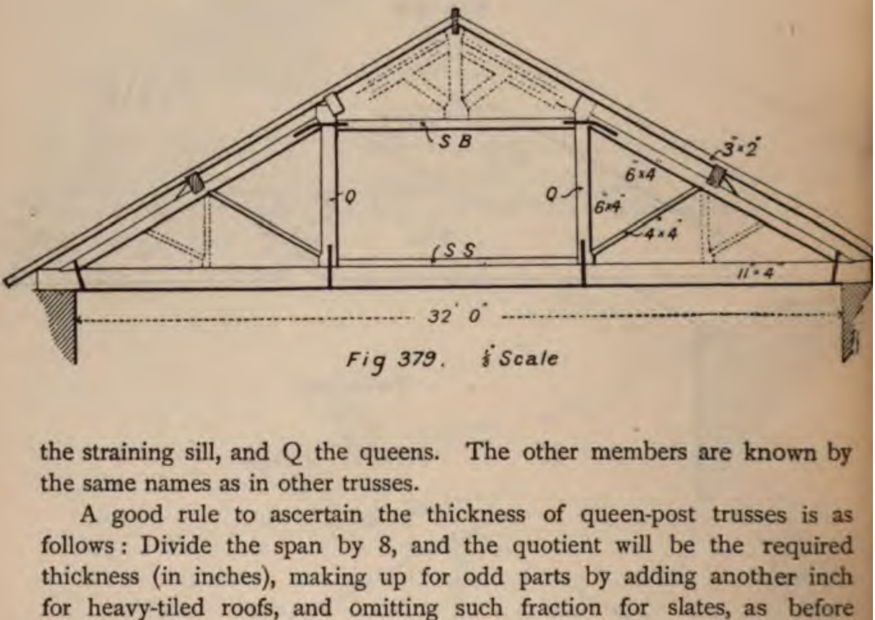


Fig 379. ⅛ Scale

A good rule to ascertain the thickness of queen-post trusses is as follows: Divide the span by 8, and the quotient will be the required thickness (in inches), making up for odd parts by adding another inch for heavy-tiled roofs, and omitting such fraction for slates, as before explained.

Taking the tie-beam for 32-feet span at 11 inches deep, and principal rafters at 6 inches, by adding 1 inch for every 5 feet additional span, we can arrive at their depth for the different roofs.

The struts and middle of the queens are usually square.

Coming to the details of the joints, we find they are similar to those for a king-post roof; except, of course, those at the head and foot of the "queens," which are as shown on fig. 380.

Wood and Iron King-trusses.—Fig. 381 is an illustration of a wood-

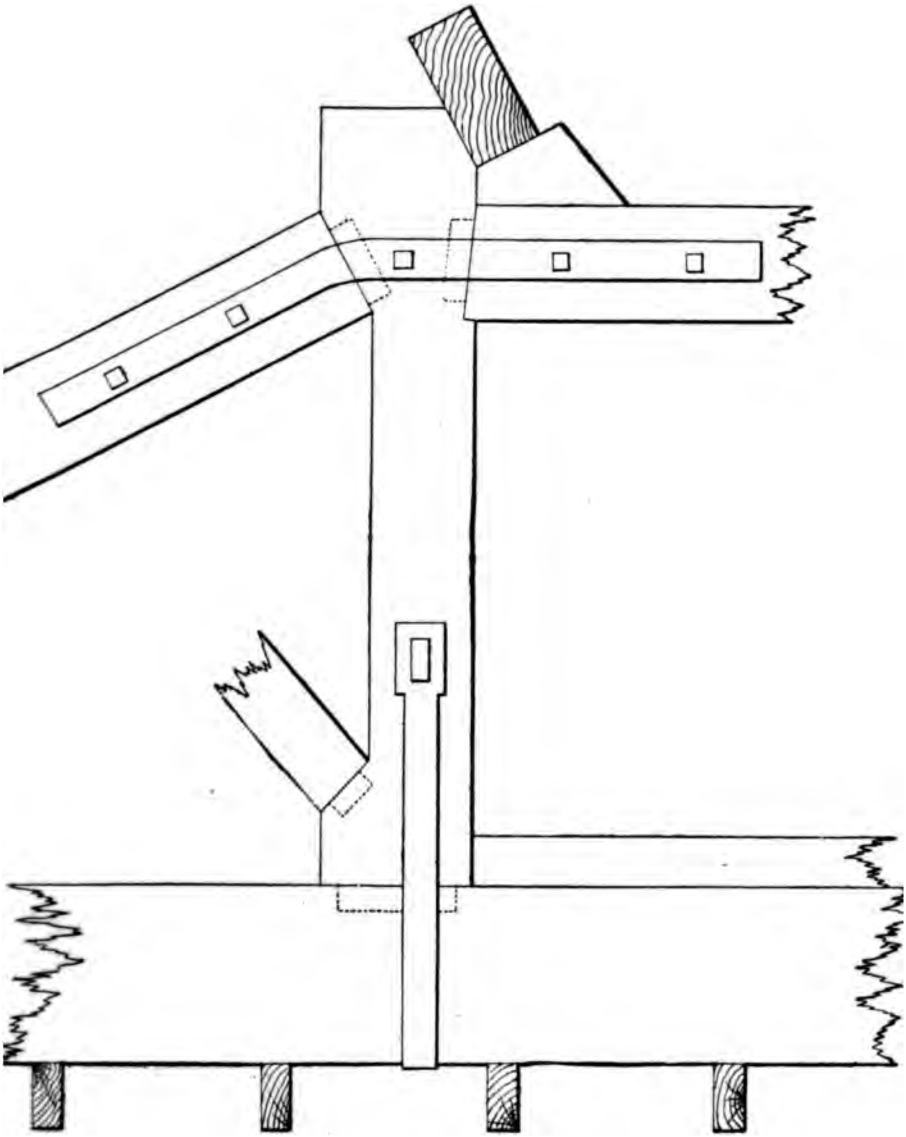


Fig 380

truss, with an iron king-rod, the joints of which are explained in detail figs. 382 and 383.

From these it will be seen that a wrought-iron king-bolt, ¾ inc

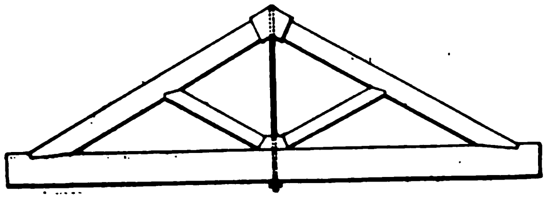


Fig 381 . . ⅛" Scale

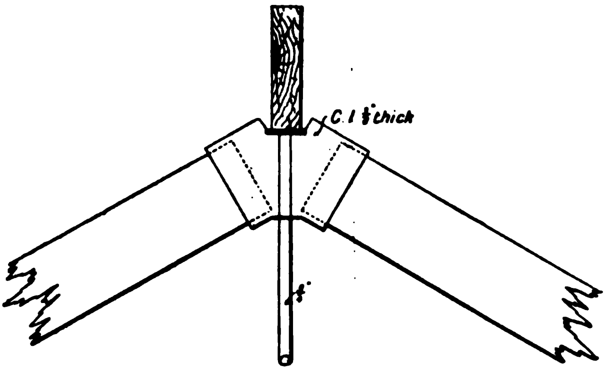


Fig 382

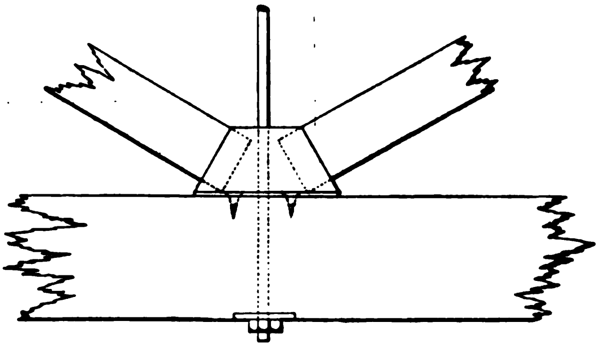


Fig 383 1" Scale

diameter, slings up the tie-beam to the apex, where a cast-iron h receives the principal rafters into sockets on either side of the king- which goes through the hollow cast-iron work, and is bolted up from ab the apex to the bottom of the tie-beam. The struts are likewise recei by cast-iron sockets, screwed on to the top of the tie-beam through which the king-rod is placed.

Sometimes, to save expense, a plate is fixed on the underside of the tie-beam and bolted through, to secure the shoe-plate for the struts.

Sometimes the struts butt against each other round the king-rod, as fig. 384; from which it will be seen that there is nothing to keep them in position, laterally, except the spikes which fix them to the beam. This is called a *strut and beam* joint.

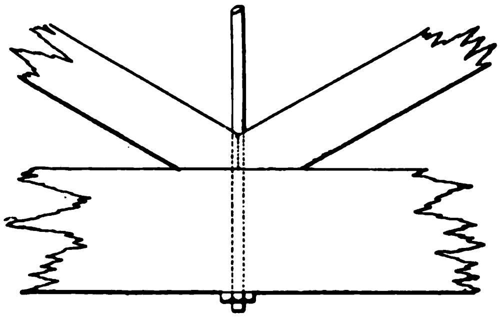


Fig 384 1" Scale

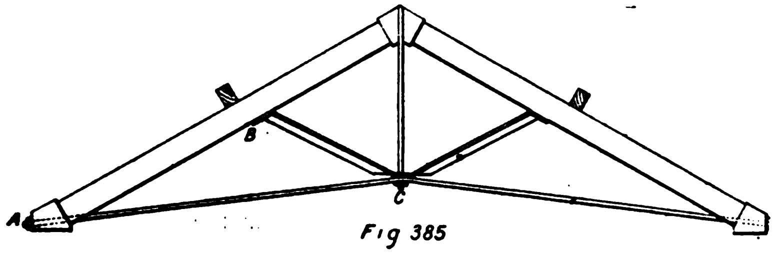


Fig 385

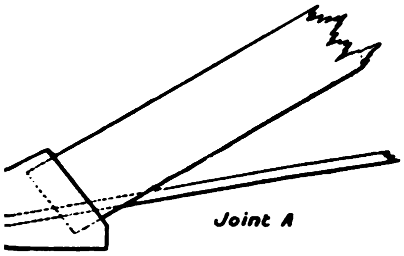


Fig 386

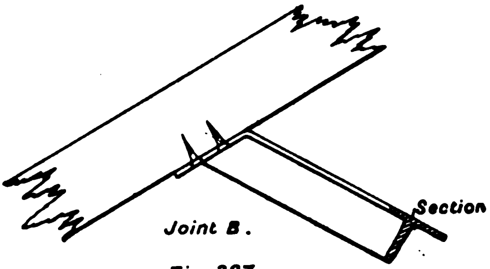


Fig 387

Another form of this kind of roof-trussing, with wood and iron, is as fig. 385; which is all iron except the principal backs, wrought-iron being used for struts, ties, and king-rod, and cast-iron for heel and head sockets.

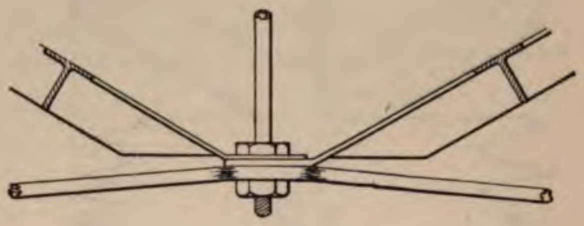
The details of joints and construction are:—

Fig. 386 represents joint at A.

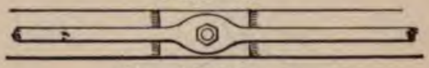
Fig. 387 shows the joint at B.

Fig. 388 that at C.

Therefrom the student will see that wood struts could be substituted for the Tee irons, if thought advisable; and the tie-rod could be forged out to a sufficient width to give them a bearing on each side of the king-rod.



1" Scale
Joint C.



Plan looking up
Fig 388

Wood and Iron Collar Truss.—Another form is as fig. 389, the joints of which it is needless to enlarge upon. The student can make them out from others of a similar kind already illustrated in the course of these notes.

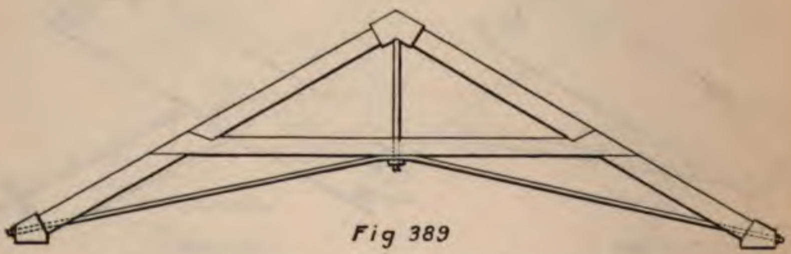


Fig 389

Queen Flat Truss.—The next form of roof to which the student's attention should be drawn is the queen-post roof, used as a flat roof over the straining beam; the only points new to the student being the suspension-rod in the centre, and the beam and strut joints under the straining beam which carries the bearers of the flat to be boarded and covered with lead or zinc (fig. 390).

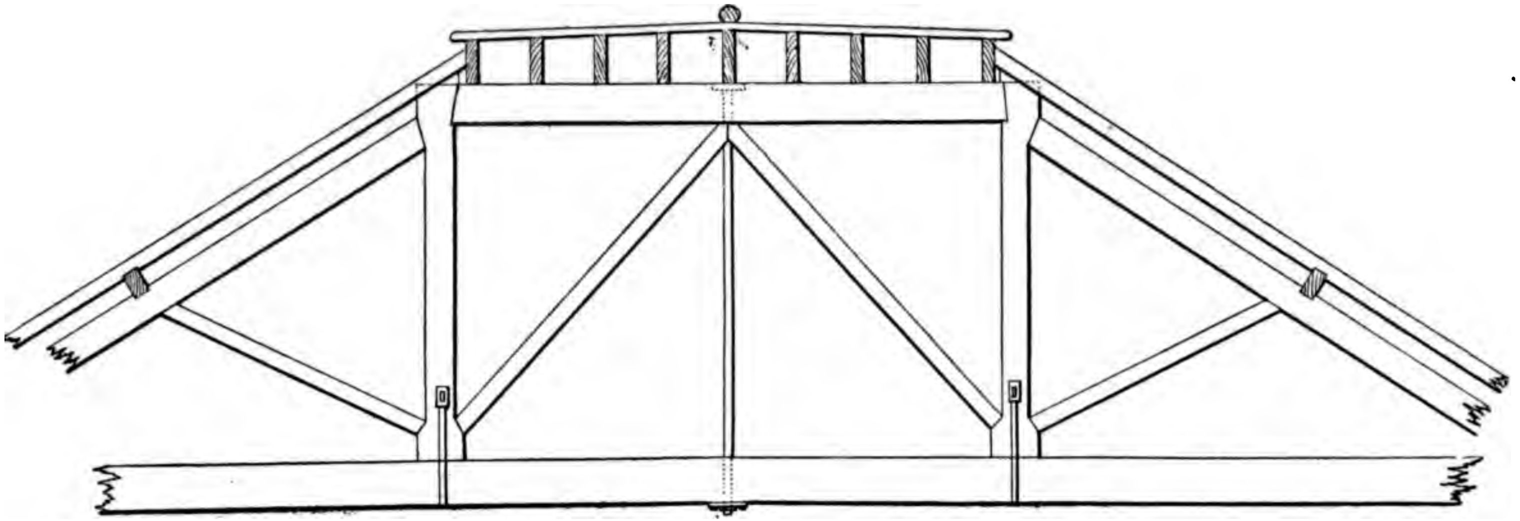


Fig 390

Mansard Roof.—The Mansard roof (invented by a Frenchman of that name with a view to utilising the roof spaces as much as possible) is a roof similar to fig. 391. The joints are all known to the student, and it only remains to be said that this form of roof can be very much strengthened by the tie-beam being made the head of a bolted and trussed partition below, especially if queen-trussed with intertie built into the enclosing walls, or a partition with no openings in it.

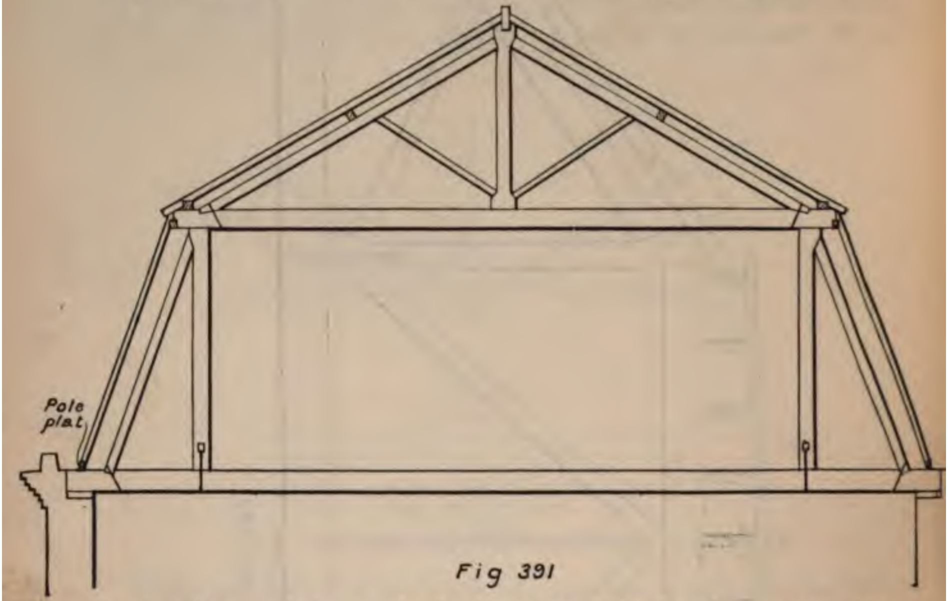


Fig 391

Occasionally cases crop up where trusses are necessary, but cannot be used for various reasons, and the cross-walls are too far apart for ordinary purlins; recourse then has to be made to trussed purlins or ridges, but sometimes the ordinary purlins are *flitched* to give them additional strength (*vide ante*, fig. 295), or *trussed* (as figs. 296 and 297, Chapter VIII.).

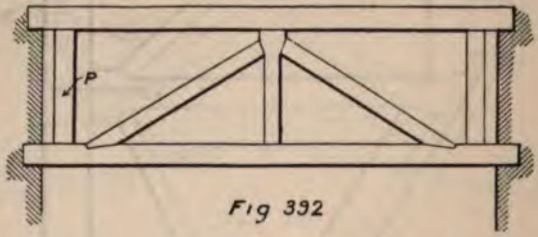


Fig 392

Another way is to build up an ordinary framing, as fig. 392, the joints of which have been already illustrated in different places, or under preceding headings. Here, the wall posts, P, are called *puncheons*; and the framing may be either of the king or queen-post class, according to circumstances and the bearings between walls. The dimensions of the timbers also follow the ordinary rules.

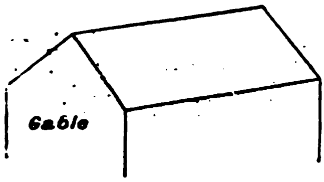


Fig 393

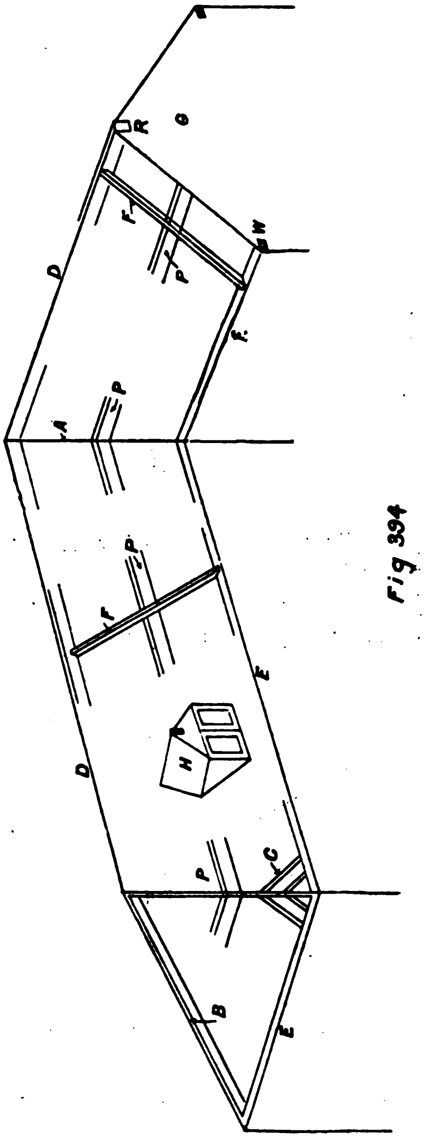


Fig 394

Details of Roofs.—*Hips* are the external angles made by the junction of the roof and its return round the ends, where the end walls are not carried up to the underside of the rake of roof to form *gables*, as fig. 393.

Valleys are the converse of hips, and *jack* rafters are the short rafters which run between the hips or valleys and the wall-plates.

Dormers are gables on a small scale, or vertical windows placed on the inclined plane of a roof.

Fig. 394 illustrates a returned roof, with hips and a valley, showing generally the positions of some of the parts hereinbefore described, as particularised in the accompanying reference—viz., A, valley; B, hip; C, jack rafters; D, ridge; E, eaves; F, common rafters; G, gable; H, dormer; P, purlins; W, wall-plate.

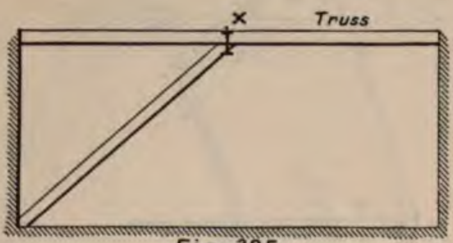


Fig 395
Plan

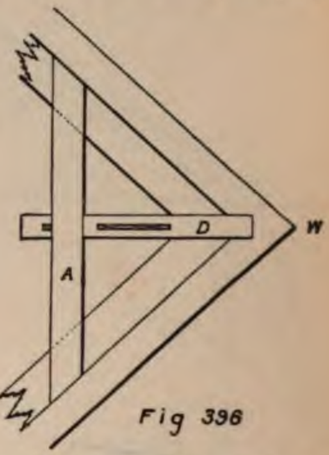


Fig 396

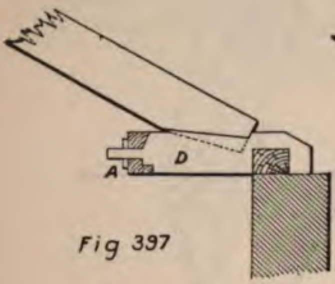


Fig 397

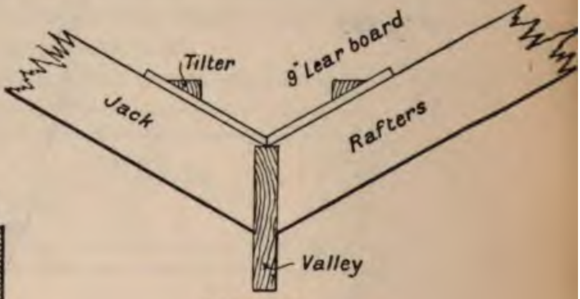


Fig 398

Hips, on account of their great length, are sometimes made the principal rafter of half-trusses, which are bolted with angle irons to the king-posts of the main trusses, as at X, on fig. 395; and they are framed at the external angles into *dragons*, D, which are halved over the angle of the two wall-plates, W, and "tusk-tenoned" into an *angle-brace*, A, which stretches from wall-plate to wall-plate, forming an equilateral triangle with them. Fig. 396 is a plan and fig. 397 a section explaining the foregoing details.

Valleys are treated in a similar way, but being internal angles, have often to be covered with lead, which means boarding as a foundation, as fig. 398.

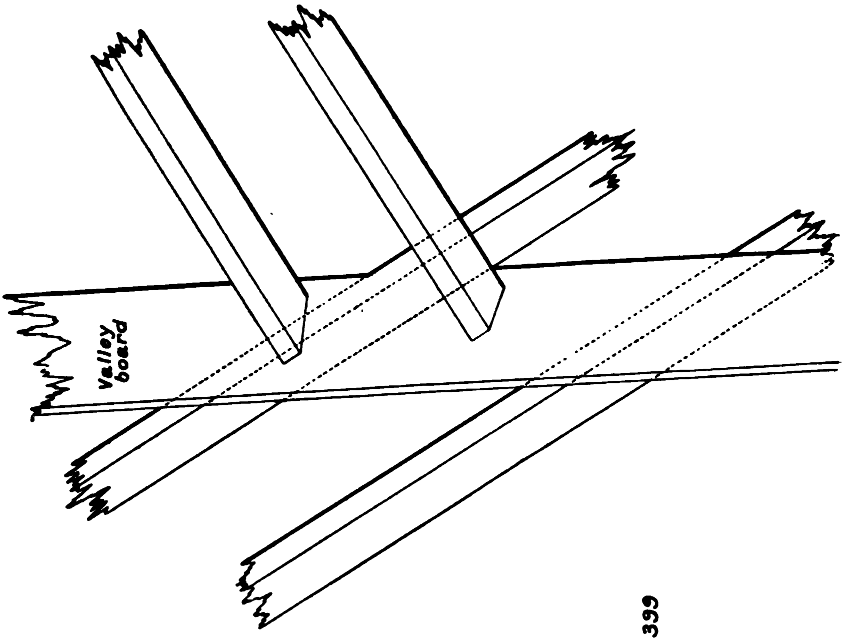
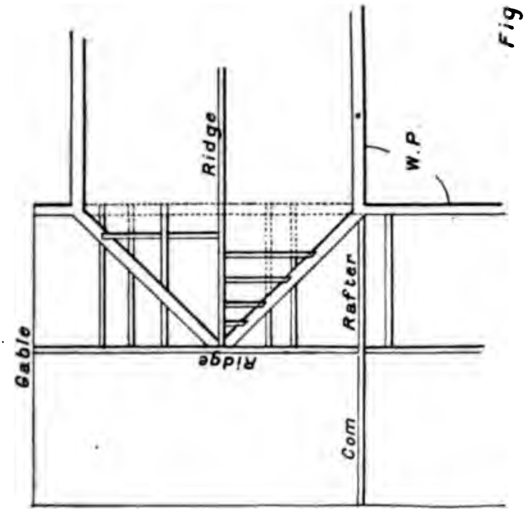
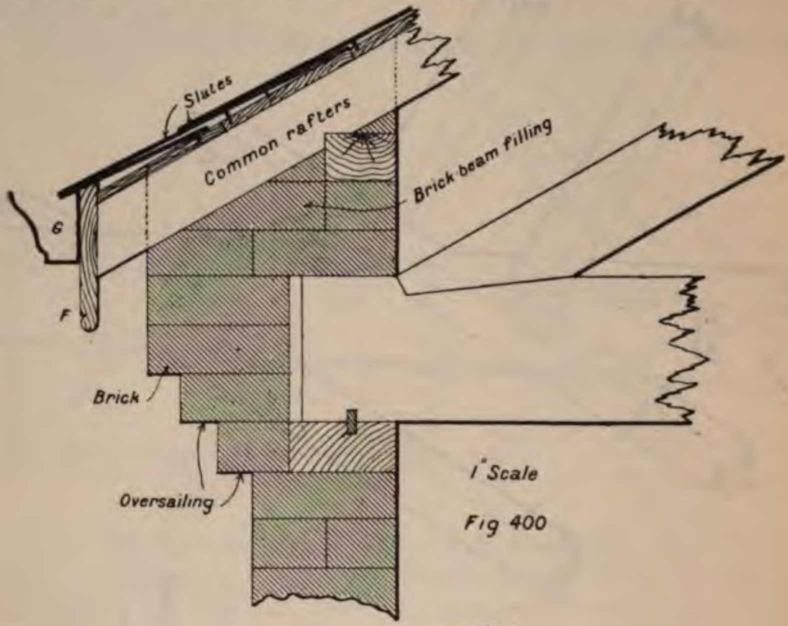


Fig 399



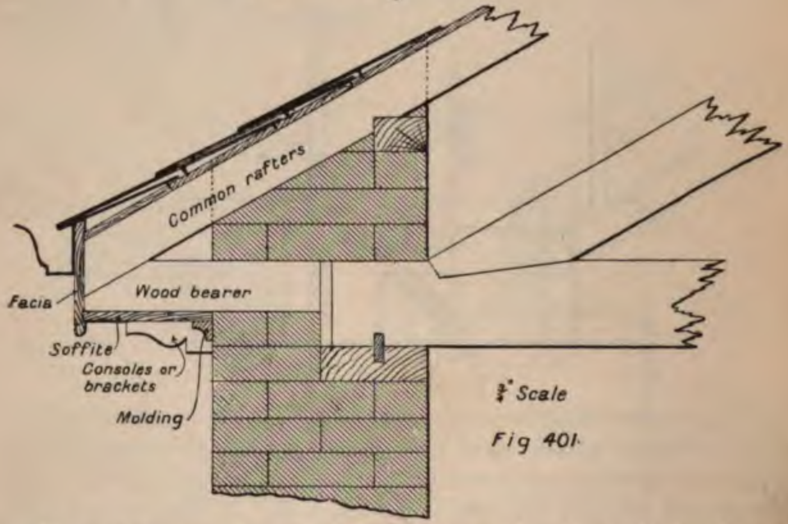
Instead of valley-rafters one roof is sometimes run through, and a valley board put on it, from which the short or jack rafters spring to the ridge, as fig. 399.

The *eaves* of roofs are at the feet or bottom of the rafters, where all the rain-water is collected into cast-iron gutters, hanging over the walls, from which it is taken by cast-iron downpipes to the drains below.



1" Scale

Fig 400



¾" Scale

Fig 401

Fig. 400 represents an overhanging eaves with a fascia, F, fixed to the feet of the rafters, for carrying the cast-iron moulded guttering, G; while fig. 401 shows the same fixed to a wood cornice.

Fig. 402 represents a cast-iron half-round gutter, fixed by wrought hanging irons to the wrought and cut rafter feet; these irons can also be fixed on the top of the rafters, but they are awkward if the gutter should afterwards have to be altered, necessitating taking off a few courses of the slates or tiles to get at them.

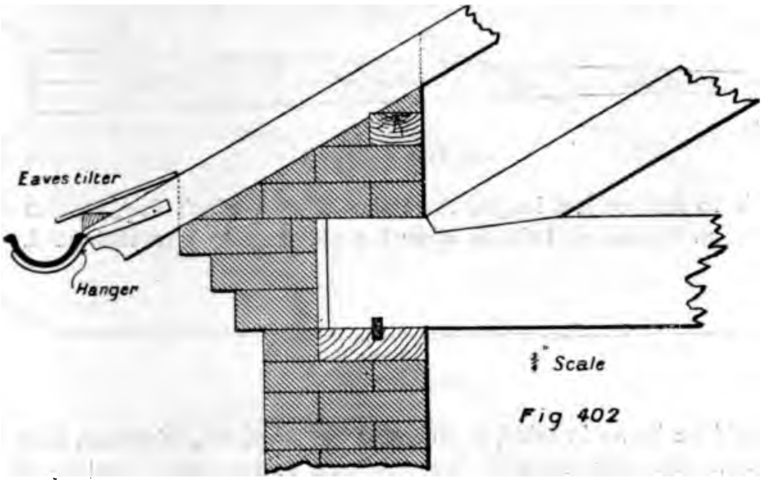


Fig 402

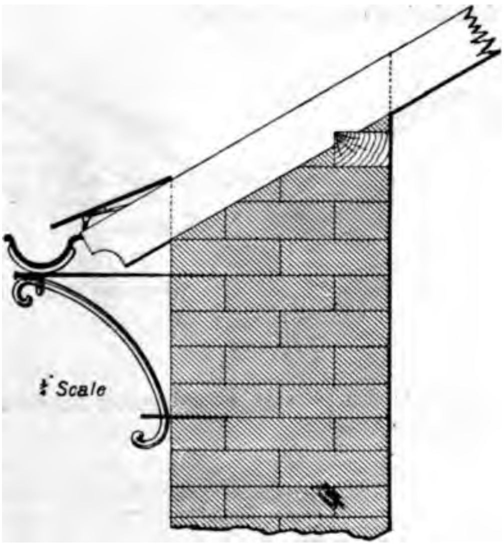


Fig 403

Fig. 403 represents the same, but the gutter is carried by wrought-iron brackets, fixed to the walls, which looks clumsy in work.

Gutters—i.e., those boarded and lead-lined—are laid either behind parapets and chimneys, or between M roofs. They should never be narrower than 9 inches at the bottom or starting-point, should rise about 1½ inches in no more than 10 feet lengths, at the outside, and between

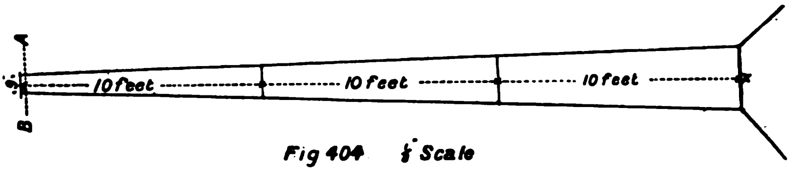


Fig 404 ⅛" Scale

each 10 feet, or less length, there should be a 2-inch drip, to give the water an impetus, and also to allow the plumbers to joint their lead. It

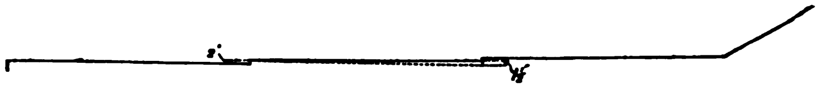


Fig 405

should be borne in mind, in arranging the drips, etc., of gutters, that the sun interferes with lead when in long lengths, so that drips should be placed within the 10-feet limit where practicable.

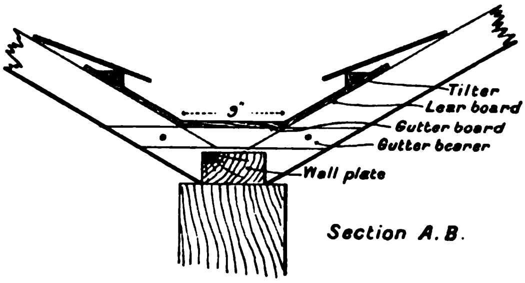


Fig 406

Fig. 404 represents the plan of a lead gutter between two roofs, M, and fig. 405 a longitudinal section.

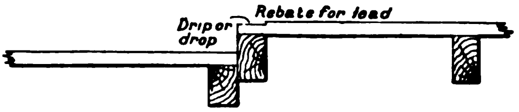


Fig 407. Section C.D.

Fig. 406 is a cross-section of such a gutter, and fig. 407 an enlarged longitudinal section through a 2-inch drip.

It is always better to nail a feather-edged fillet on the face of the drip, to make the angle the more obtuse for dressing the lead over, as fig. 408. Moreover, care should always be taken that the boards carrying the lead are laid in the direction of the fall, and *not* crosswise.

The *lear-boards* and tilter are also fixed at the top return, X, fig. 406, as at the sides.

Cesspools are sunk boxes, placed at the lowest points, to collect the water previous to discharging it, through a pipe fitted to the bottom of the cesspool, into the rain-water pipe, or, better still, into a head connected to the downspout (fig. 409). The heads allow of the lead bend to the cesspool being open at both ends and accessible, which is a great convenience when they get stopped up with leaves—a very common occurrence. It is more convenient to have spout *troughs* through the walls from cesspool to head, when circumstances will allow of it.

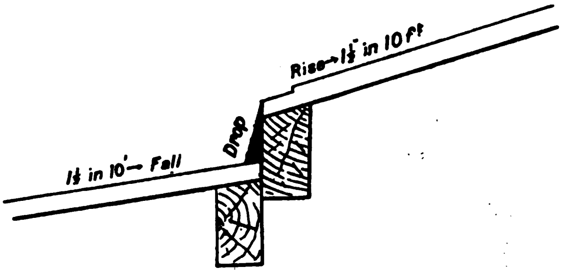


Fig 408

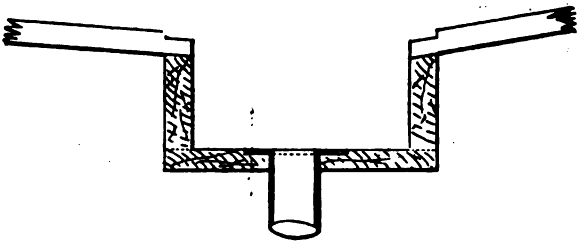


Fig 409. Section of Cesspool

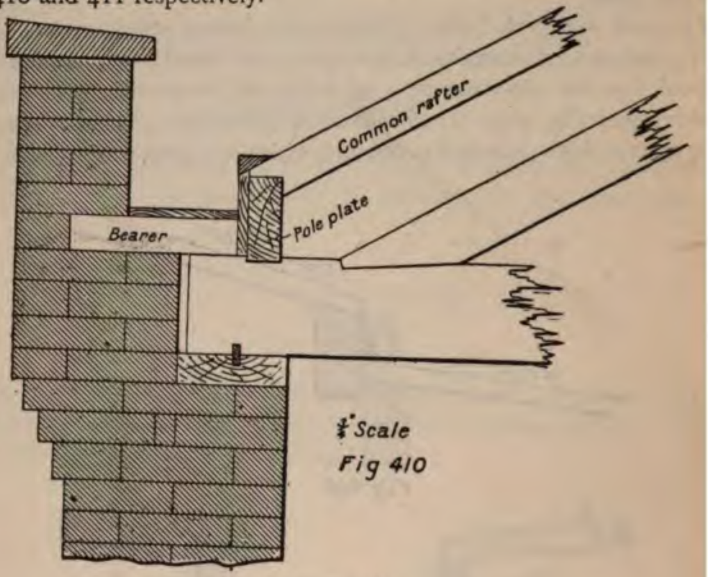
The position of these cesspools has to be regulated, of course, to suit the elevations of the building and the position in which the downpipes can be placed.

The angles of cesspools, as well as the bottoms, should be dovetailed together to make a satisfactory and good job, though they are often only tongued together. Their size varies, of course, according to circumstances, the standard being 12 inches square and 9 or 10 inches deep.

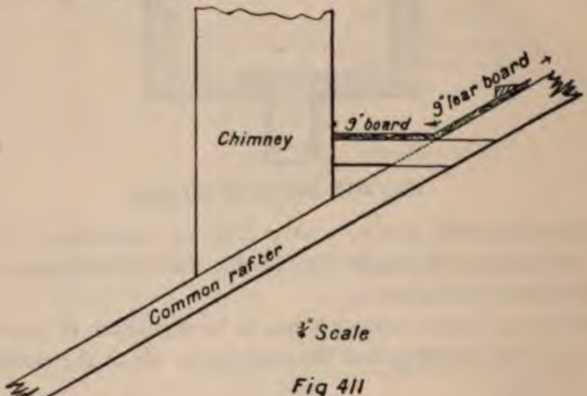
Lead Flats.—The same rules apply to lead flats as to gutters, the falls of which are regulated by the bearers, which, of course, are stronger according to the increased bearing.

The rolls, etc., necessitated by the widths of lead or zinc will be d with in Chapter XIV., on Plumbing and Zincwork.

Gutters behind parapet walls or chimneys are under the same r with regard to falls, etc., as last described, and are constructed simila figs. 410 and 411 respectively.



¼" Scale
Fig 410



¼" Scale

Fig 411

Gutters, owing to their rise up between the roofs, etc., increase in wi consequent on the greater distance between the eaves of the roof as t get higher up (see fig. 412); and they must be shown to increase in wi on all plans accordingly.

All leadwork in gutters or flats, where traffic would gradually wea away, should be protected by *snow-boards,* which consist of arc s, across the gutters, supporting laths or lattice-work no more than h apart, running longitudinally with the fall. The bearers must be l when laid across to allow the water to pass, and the spaces between

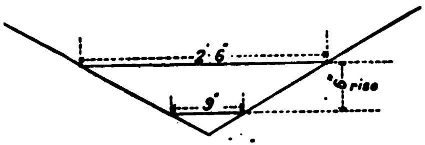


Fig 412. ⅛ Scale

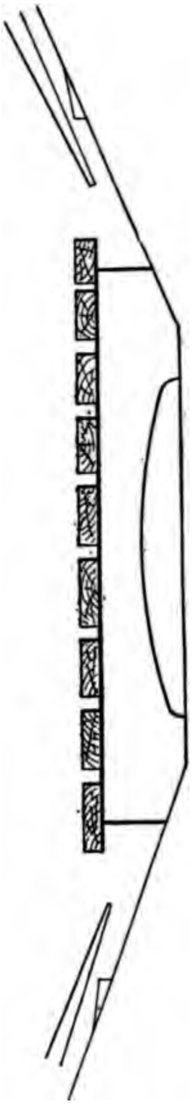


Fig 413

laths should never be more than $\frac{3}{16}$ inch in width, as snow will get ›ugh wider interstices, freeze, expand, and upset the laths, besides *forcing* water under the drip or drop, and causing a backing up, and consequently ng the water within the roof when the thaw sets in (*vide* fig. 413).

CHAPTER XI.

IRON AND STEEL.

Pig Iron—Cast Iron—Cast Malleable Iron—Wrought Iron—Rolled Girders and Joists—Steel.

It is only proposed to deal with the subject of iron and steel from a builder's point of view, and not as would be required for an engineer or ironfounder, a brief *résumé* being given of the various points of which the student is required to have some knowledge.

Pig Iron.—Wrought and cast iron and steel are all made from *pig iron*, extracted from the natural ore by the smelting process, which consists of heating the ore in a furnace, after it has been crushed into smaller particles, and then roasted or dried.

When in the furnace limestone is added to the prepared dry ore to extract its impurities, and a hot or cold blast passed over the aggregate, resulting in the molten metal leaving the lighter and more fusible impurities at the top, and sinking itself to the bottom, whence it is run into long channels with branches formed in sand called the "sow and her pigs,' which gives this iron its name.

This "pig" or unpurified cast-iron is divided into the *foundry* and *forge* qualities, distinguished by the combination and amount of the carbon each in the first instance contains, the resulting cast-iron having a proportion of from 2 to 6 per cent., while steel should only have from 0·15 to 2·00 per cent., and good wrought-iron should be practically free from it.

Carbon, although it plays such a very important part in iron and steel, is considered a foreign matter, the effect which it has on the different metals depending on the nature of its combination. When it is in *chemical* combination in cast-iron it produces a white, hard, and brittle metal, only fit for the commonest uses, such as sash-weights.

On the other hand, a *mechanical* mixture, in which particles of carbon appear as black specks, giving it a grey appearance, produces superior metals, that of a light grey colour being hard and brittle, and suitable for heavy castings, while the dark grey is weak, and only used for light ornamental work; but a medium quality in colour gives us a strong and durable metal, of weight-carrying properties, capable of resisting considerable pressure.

Cast Iron.—White cast-iron is made from forge and grey from foundry pigs, each of which is remelted and run into the moulds formed in sand according to requirement.

Good cast-iron should be of uniform toughness, with an even surface and straight edges, to show even shrinkage, while a *fracture* of the best quality should be clean and bright, of a bluish-grey colour, and free from any air or sand-holes, the presence of which can easily be detected in the mass by the hollow sound given when the metal is hammered.

All angles of castings should be gradual, to prevent uneven shrinkage, as a thin portion will naturally cool much faster than a thick one; and where these two are adjacent their junction must be gradual, so that the thin part shall not set first and act as a check on the other, and cause cracks. This point is of especial importance in castings for girders and cantilevers, on account of the great difference there is between the power of cast-iron to resist compression and tension, the former being 38 tons per square inch, and the latter about 8 tons ultimate strength.

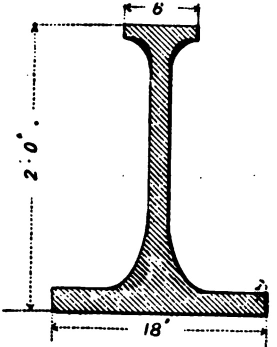


Fig 414
Scale $\frac{1}{8}$"

The "safe" load is about 8 and $1\frac{1}{2}$ tons per square inch respectively, or nearly in the proportion of 1 to 6; and when it is considered that both flanges of a girder are subject to the same amount of stress, the top one of compression and the bottom of tension, it is obvious that their respective sectional areas, to resist their strains, must be in the proportion of 1 to 6, otherwise there would be either a waste of metal or lack of strength in one or the other.

Therefore the section of a cast iron girder must be as fig. 414, the bottom flange having six times the area of the top one; while the *web*, as the vertical portion is called, must make a gradual junction between the two at top and bottom.

"Girders," it will be understood, are bearers having supports at both ends, while a "cantilever," as fig. 415, has only one end fixed; and consequently the strains on the flanges are the reverse of those of girders (as will be explained in Chapter XXIV.), necessitating also the reversal of the section in cast-iron cantilevers, which should be, therefore, as shown in fig. 416.

Cast Malleable Iron.—"Cast malleable iron" results from the extraction of a proportion of the carbon out of cast-iron by means of embedding the casting in oxide of iron, and reheating it in an annealing or softening oven. This kind of iron combines the qualities of wrought and cast-iron, and is used for intricate work in wrought-iron specialities, being welded to the *wrought*-iron plainer portions, which cannot be done with cast-iron.

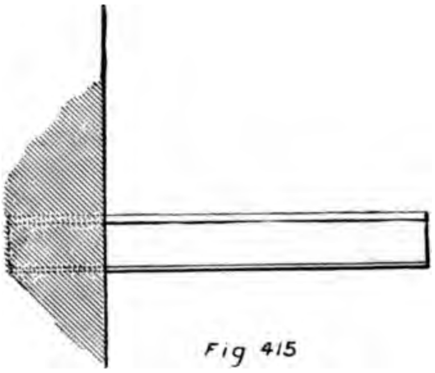


Fig 415

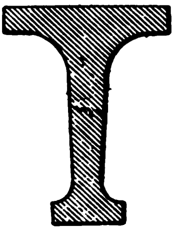


Fig 416

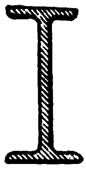


Fig 417

Wrought Iron.—"Wrought iron," which has now, to a great extent, superseded cast-iron, except for ornamental purposes, is the product of "Forge Pig," the resulting metal containing not more than 0·15 per cent of carbon. The excess of carbon, it is obvious, must be extracted from the iron, the usual processes being as follows:—

The pig iron is first *puddled* or melted clear of any fuel, but with other substances (containing oxygen) to take out the remaining carbon; and when this is done the metal is collected and cooled into lumps, which are then *shingled* or placed under a heavy hammer, by which the iron is consolidated, and all other foreign matters are crushed out.

The *bloom*, as it is called, resulting from this hammering, is then rolled, while still hot, into *puddled bars*, which are the first and lowest quality of wrought-iron. As manipulation improves the tenacity and strength of wrought-iron, these puddled bars are cut up, piled, heated, and rolled as before; forming the *merchant bar*, or second quality of wrought-iron; and a repetition of this process produces the *best bar*, B, or third quality; while *Best-Best*, B B, and *Best-Best-Best*, B B B, are the outcome of further repetitions—each such operation having the effect of giving the iron a more uniform fibrous nature.

Good wrought-iron is of a very tough, fibrous, weldable nature, capable of elongation, under certain weights, with little proportionate contraction of area—varying from 10 to 20 per cent. according as it is across, or with the fibre of the metal. It has also the power of *elasticity*, or going back to its original size and section, after the weight has been removed; though it can be *fatigued* by a continuance of that weight, which is said to cause a *permanent set*; meaning that the iron then stops at the position to which the load has drawn it, and this is said to be its *limit of elasticity*, extending to one-half its ultimate strength. It should be capable of bearing 24 tons per square inch, ultimate tensile strain, and about 20 tons of compression and shearing; equivalent to safe loads of about 5 and 4 tons respectively. These two powers of resistance are so much more nearly equal in wrought than in cast-iron, that top and bottom flanges of a girder may be made alike, with little waste of material or forfeiture of strength.

Rolled Girders and Joists.—Therefore girders or joists are rolled to sections, as fig. 417; and, in addition, they can be built up (in wrought iron) to any size, section, or design; because the iron can be welded, riveted, bent, rolled, or otherwise worked to any form, which cannot be done with cast-iron on account of its brittleness.

The surface of the *fracture* of good wrought-iron, under a weight applied *slowly* and *gradually*, should be stringy in appearance, as if every little fibre had held out to the last on its own account, some with greater success than others; while the fracture under a *sudden* shock would be of a more crystalline nature, its coarseness or fineness indicating its quality; the same deductions being drawn from the fine or coarse strings of a gradual fracture.

Iron contracts or expands $\frac{1}{150000}$ of its length for every degree (Fahrenheit) of temperature; and this must be taken into consideration in designing large wrought-iron structures.

Phosphorus is said to make wrought-iron *cold short*—*i.e.*, not capable of being bent and worked, as it should be, when cold; while the presence of sulphur has the opposite effect, rendering it *hot short*.

Steel.—*Steel* has a tensile strength of 32 tons per square inch, ultimate or breaking weight, and the same of compression with shearing at 24 tons—each of which, it will be noticed, exceeds the power of resistance of wrought-iron, which it has superseded; the kinds generally used for buildings being Siemens-Martin and Bessemer Basic—the former usually preferred on account of its greater toughness, though the latter rolls into more shapely joists, and has bye-products valuable to the manufacture This difference is not worth considering in ordinary buildings, and more over the Bessemer Basic is a trifle cheaper.

Steel contains from 0·15 to 2 per cent. of carbon, the amount bein regulated either by addition to wrought or extraction from pig-iron, a hereinafter explained. It has the strengths previously mentioned, wit greater elasticity, and combines most of the useful characteristics of bot cast and wrought-iron ; in addition to which it can be hardened or softened which is called *tempering*,—the former being done by reheating an *sudden* cooling, and the latter by reheating at a lower temperature an *gradual* cooling.

The various kinds of steel are made as follows :—

Tool Steel, as the name implies, is used for all kinds of instrument including knives, and other cutting tools. It is the product of "cementa tion," which consists of the cutting up of pure wrought-iron bars an heating them with charcoal at a high temperature, forming *Blister Ste* —so called because of the blisters made by the process on the face of th iron. It is then reheated and rolled, forming *Spring Steel*; while th *single* and *double shear steels* are the results of further cementations, aft which the metal is hammered together by a large "tilt" hammer.

Cast Steel includes the following different methods, the resulting materia being used for cutlery, railway rails, and wheels, armour, boiler plates, etc. :—

The *Bessemer* process includes the melting of pig-iron with oth fluxes, to produce pure wrought-iron, to which the required carbon added in the form of "Spiegeleisen."

The *Siemens* process substitutes Mokta ore for the Spiegeleisen ; while

The *Siemens-Martin* method, wrought scrap iron is added, to give t required carbon.

The resulting metal is then rolled, according to Whitworth's patent, compress the mass and get rid of the holes contained in all cast-ste These last processes make the steel which is usually rolled into girde etc., for building purposes.

Mild steel can be made by the above processes, but contains fr 0·2 to 0·5 per cent. of carbon only, and is superior to wrought-iron.

Wrought-iron and steel, by the equality of their different powers, ha a great advantage over cast-iron, which they entirely supersede for m work in which the structures are subject to both tension and compressi alternating in the same flanges, especially in continuous girders, etc. (explained in Chapter XXIV.).

When wrought-iron or steel girders meet from different directions ov columns they must be grouped together by angle plates, bolted to th webs of each girder, so that they can assist each other to make up fo their small bearings, which should scarcely ever be less than 9 inche for weight-carrying joists, girders, etc. Figs. 418 and 419 illustrate what is required at such junctions over columns.

To guard against corrosion, which gradually reduces their strength, these metals may be variously treated, by being:—

1. Boiled in tar;

2. Plunged into oil when red-hot, or coated with boiled oil;

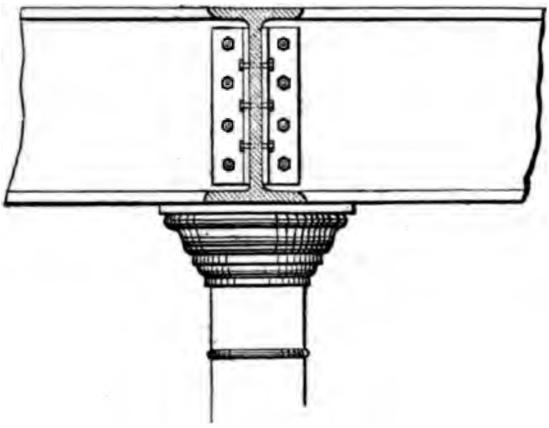
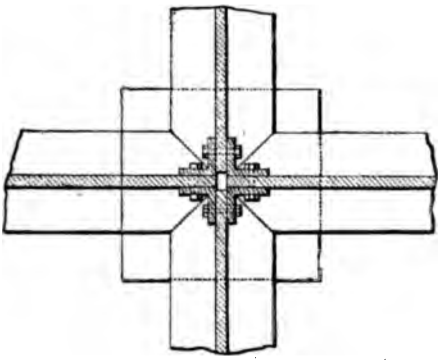


Fig 418. 1 Scale



Section thro' Webs (looking down) Fig 419

3. Galvanized by a covering of zinc; or

4. Painted with oxide of iron instead of lead-paint, in order to give them some protection from atmospheric and other influences, which tend to injure them, and bring about deterioration of strength; and just lately it has been found that by adding a small proportion of aluminium to the steel in the manufacture the corrosion, to which it is greatly and prejudicially subject, can be considerably reduced.

CHAPTER XII.

RIVETS AND RIVETING.

Riveted Work—Hand Riveting—Machine Riveting—Forms of Rivets—Size of Rivets—Methods of Riveting.

Riveted Work.—Riveting is the means by which "first-class" wrought-iron and steel framings are connected together, and especially girders built up of several members, the common class of work being connected by bolts in lieu of rivets. It can be done by hand or by machinery, and consists of circular tapered wrought-iron pins, as it were, similar to fig. 420, with heads of various patterns, which are driven when hot into holes concentrically made in the two pieces of wrought-iron or steel to be connected together. The rivets should be made of the very best (B B B) wrought-iron, the Staffordshire and Yorkshire qualities being the most suitable, as they are capable of withstanding an ultimate *shearing strain* (to which rivets are subjected) of about 25 tons per square inch, with a contraction of area of from 40 to 50 per cent., and elongation of 20 per cent., before a permanent set takes place.

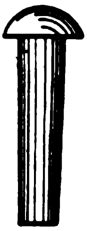


Fig 420

Good rivet-iron should admit of being doubled up, when cold, without showing any signs of fracture; and the heads, when hot, should be capable of withstanding hammering down to almost a flattened thin surface before cracking at the edges, and they should allow of a hole being punched through them of nearly their own diameter without cracking round the hole.

Inasmuch as the entire strength, and consequently the successful adaptation to its work, of the structure or girder often depends *wholly* at certain points on these rivets—which have to transmit unaided a complete series of great and heavy strains from one plate or member to another, which they are connecting together—it is absolutely necessary that the best rivet-iron should always be used, and fully up to the specification on which the calculations for the girder or framing have been based; and it is also necessary that the operation of riveting should be performed in the best, soundest, and most workmanlike manner.

Hand Riveting.—The method of proceeding in "hand riveting" is as follows: A gang, of two boys and three men, is set on to each job, the boys having to heat the rivets in a portable smith's forge adjoining the work, and to hand them up in buckets, when hot, to one of the men who stands under the plates to be connected up. This single-handed man—having previously knocked out of the rivet-holes a punch with which he has tested them for position, so as to see that the holes in the plates coincide properly and are concentric—pushes up the red-hot rivet through the holes, and places his hammer on its head underneath. On the pin of the rivet coming through the hole, and when the man underneath has secured his iron to its head, one of the two men who are at the top of the plates then hammers the tail of the rivet down, so that it fills the holes completely. It is to be noted, that it cannot be driven downwards again through the plates, because of the man's iron below; and, as the plates should previously have been hammered close together, the metal shank cannot be squeezed between the plates, and so keep them apart afterwards.

This being done, the second man at the top then places an iron die over the red-hot iron, which has now been compressed within the holes, and the other hammers it down, so that the die forms the upper end or other head of the rivet. The rivet-heads may be of various patterns, as hereinafter explained. The whole of this process only lasts a few seconds, and on the iron cooling it contracts and pulls the plates together by means of the ends of the pin of the rivet, as the sketches will explain.

Machine Riveting.—"Machine riveting," of course, has to be done in the shops at the ironbuilder's yard or works; so that only certain parts, though often the majority, can be riveted together, by machines, which work on similar lines to the process of hand riveting, but have the advantage of making both ends of the rivet at the same time, while the very great pressure, oftentimes from 50 to 60 tons, compresses the iron and fills up the rivet holes so much better than when done by hand; and consequently, when the rivets cool and contract, they have greater power to pull the plates together. Indeed, cases have been known where the pins of machine-riveted work have been so tightly fitted in the holes, that when the heads have gone, or been removed, the pins have kept the plates together; and, moreover, the pins have even had to be "drilled out," when required, because they could not otherwise be got out. Hence it will be seen that machine riveting is far superior and better than that *clenched* by hand; and not only that, but the work is done so much cheaper by machinery.

The employment of bolts and nuts, to connect ironwork together, such as plates, is not to be compared, in point of strength and efficiency, with rivets, which pull the plates together in themselves, when they cool, after having been hammered down, whereas bolts can only be screwed up to the plates, so that the tightness of the connection and the perfection of the work depend solely on the thread of the bolt and nut.

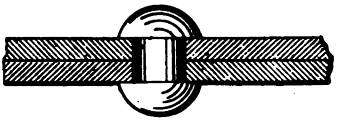


Fig 421

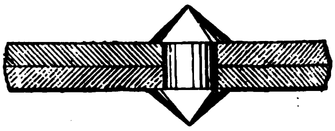


Fig 422

Forms of Rivets.—The different classes of rivets are distinguished by their different-shaped heads, and the different modes of riveting by the order in which the rivets are placed, and the number of rows of them. Among the different kinds of rivets the chief are as follows:—

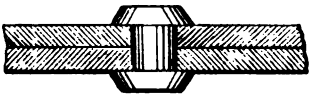


Fig 423

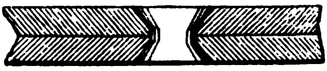


Fig 424

Snap rivets, as fig. 421, have hemispherical heads, which are forme by the die, and are sometimes called *button* or *cupended* rivets.

Hammered, *conical*, or *staff* rivets, as fig. 422, are made by th hammering of the red-hot iron to the required shape, as shown, no di being used for these.

Pan rivets are similar to fig. 423, and *counter-sunk* rivets to fig 424; these latter being used where the plates must take a truly leve bearing, which would not be possible with heads which project. The holes for these rivets are always drilled with a splayed shoulder within the plates, as the illustration explains.

The holes in the plates may be either punched in or drilled, the latter being the better mode, because, while ensuring much greater accuracy in the setting out of the pitch, they are cleaner, as will be seen by a comparison of figs. 425 and 426; and they also do not injure the fibres of the plates by the sudden shocks and hammering. Drilled rivet holes also make stronger and better connected work, so that the rivets need not be so large as for punched work.

Size of Rivets.—The rule for proportioning the size of the rivets in punched holes, as laid down by Sir W. Fairbairn, is: For the diameter of the rivets, double the thickness of the plate under ½ inch thick, the larger plate always being taken as the basis for their diameters; in plates above ½ inch thick the diameter of the holes should be 1½ times the thickness of the larger plate.

The holes are made slightly larger than the rivets, which expand when hot; and they are set out to different *pitches*, by which is meant the distance from centre to centre of the holes, the numeral used (as 4-pitch) denoting the number of diameters of the rivet from centre to centre.

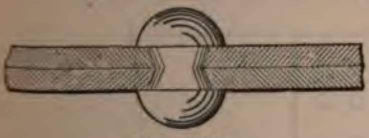


Fig 425

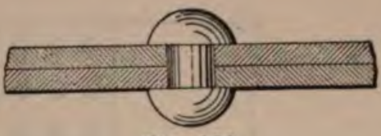


Fig 426

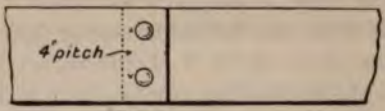
The common pitches are 4 or 5 diameters, equivalent to from 4 to 6 inches, according to the size of the rivets. In the outside row no rivet should be placed nearer than its own diameter to the edge of the plate; and punched holes should be farther away from the edge of the plate than drilled ones, because they weaken the plate more.

Methods of Riveting.—Riveting, as before noted, is distinguished by the order and number of the rows at the joint required to transmit the whole strain from one plate to the other, through the medium of the rivets themselves. *Lap* joints require only one set to convey a strain from plate to plate; while *fish* joints require two sets, the one to transmit the strain from one plate to the fish-plate, and the other set to take it from the fish-plate to the other long plate. Thus, two single rows at a *fish* joint would be called a *double* row at a *lap* joint.

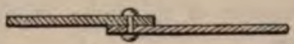
Fig. 429 illustrates quadruple *zigzag* riveting on a lapped joint, similar in section to fig. 427, while it would be called "double zigzag riveting" if the joint were fished similar to fig. 430; so that single, double, triple, and quadruple riveting differs for lap and fish joints, and others of similar character, and care must always be taken to describe them properly, according to the nature of the joint.

Lap or *lapped* joints, as fig. 427, consist of two plates overlapping one another, to be riveted together.

Fish or *fished* joints are as fig. 430 in section, which should explain itself after the previous remarks, and what has been said on fished joints in carpentry.

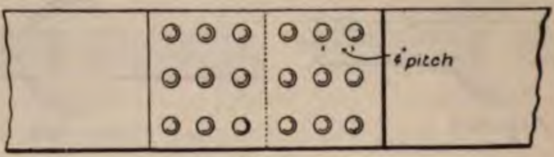


Plan



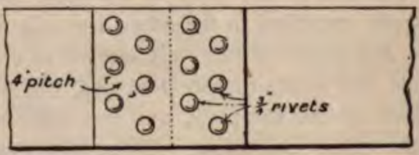
Section
Fig 427

Jump joints, in riveting, are for compression when they are employed, which should be very seldom, as the strength of the connection depends more on the butting surfaces of the plates than the rivets; and, whether these surfaces be planed or not, the very act of riveting the joint has a tendency to twist them, so that the weight is not, as it should be, evenly distributed over the butting surfaces; and where the rivets have not been calculated to take the whole strain the joint fails.



Plan
Fig 428

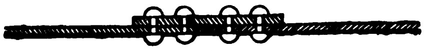
All riveted joints should be calculated and designed so that the rivets can, if necessary, take the whole strain successfully, whether it be of tension or compression, in the length of the girder, stanchion, or framing.



Plan
Fig 429

Double riveting, and other kinds, superior in the number of the rows, may be either *chain* or *zigzag* in form, as figs. 428 and 429 respectively;

the "zigzag" being considered better than the "chain," because the holes, being alternate, do not take so much out of the continuity of the fibres of the plates. For example, in fig. 429, only one hole, as it were, is taken out of one continuous fibre; whereas if it were "chain" (fig. 428), two holes would be taken.



Section
Fig. 430.

The strength of a solid plate being taken at 100 single riveted joints, by way of comparison, may be taken at 56, double at 70, and chain riveting at 85.

CHAPTER XIII.

IRON ROOFS.

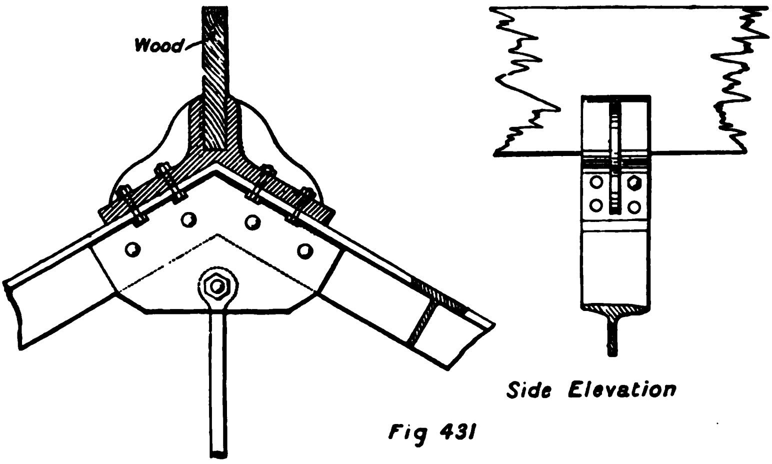
Iron *versus* Wood—Wood Members—Iron Trusses—Strains on Truss Members—Joints and Connections—Dimensions.

Iron *versus* Wood.—The student will have noticed (in Chapter XI.) how the use of iron tends to supersede that of wood in roofs originally designed and executed in wood; and as excellence in the production of wrought-iron of various forms increased, so it gradually displaced wood in the construction of roofs, first taking the parts of various members of the different trusses, for which it was in many ways the more suitable material, until now it has almost completely taken its place for the roofs of such buildings as stations, warehouses, factories, and similar constructions of a plain, substantial character, and where no ceilings are required; whereas, in trusses for the roofs of domestic buildings, the difficulty of dealing with them in a simple, practical manner precludes the exclusive use of iron—though it must be pointed out that iron is still used for the trusses only in all buildings, seeing that the purlins must necessarily be of wood to receive the rafters, which must also be of wood, for the purpose of securing the roof-boarding or laths which carry the slates or other external coverings. These wooden members—or, rather, the longitudinal parts of roofs, such as purlins or ribs, and ridges, to which the covering framing is secured—are supported in their respective positions by angle-irons and other similar means, which are, in their turn, secured by bolts or rivets to the principal rafters, etc., of the iron trusses.

Before proceeding to deal with the iron trusses themselves it will be well to fully explain this part of the subject.

Wood Members.—The ridge is generally treated as in fig. 431, being let into a special casting fitted and secured to the apex of the iron truss; or it is held up between two short pieces of angle-iron, also secured to the truss, as fig. 432.

The purlins, or ribs, which support the common rafters—or to which, when placed closer together, the boarding itself is affixed—are secured by coach screws to angle-irons, as fig. 433, bolted to the back of the principal rafter, just as cleats assist purlins on wooden trusses.



Side Elevation

Fig 431

Front Elevation

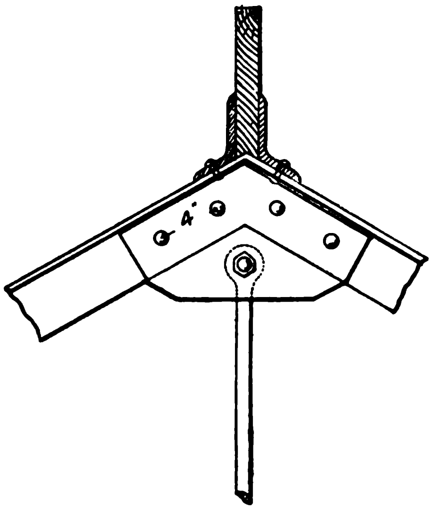
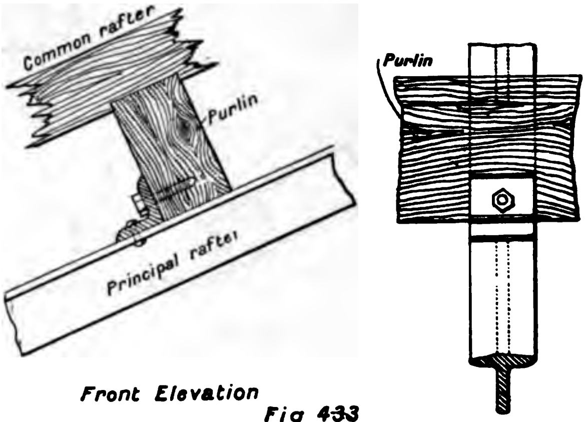


Fig 432

Iron Trusses.—Iron trusses have a lighter appearance than wooden trusses, though they can be made much stronger, according to requirements, both wrought and cast-iron being employed in their construction in the first instance. The cast-iron is used for the members in compression, as rafters and struts; while wrought-iron is, of course, used for ties and suspension rods, whether *kings*, *queens*, or *princesses*, as they are called in wooden roofs. As cast-iron was very fragile—liable to snap under sudden shocks, etc., and otherwise troublesome—it was in course of time displaced by wrought-iron, which has the advantage of being almost equally as strong to resist compression as tension—a great point in some members which are liable to both compression and tension, almost touching each other, as it were (as will be explained in Chapter XXIV. on "Strains"), so that now iron roof trusses, with the exception (and that not always) of the shoe, connecting the truss to the bearings on the supports, are completely built up of wrought-iron.



Front Elevation

Fig 433

Side Elevation

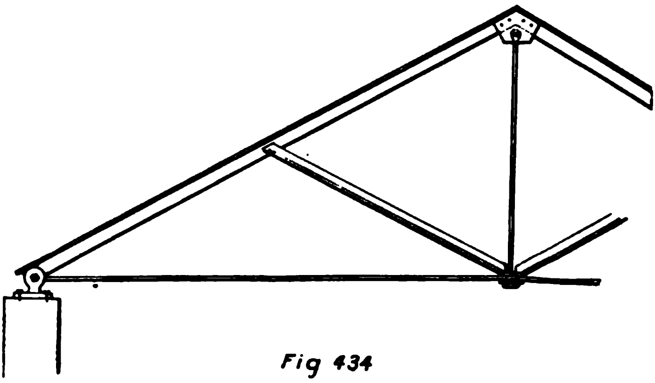


Fig 434

When iron trusses first came into vogue they were made of similar orm to wooden trusses, as in figs. 434 and 435—which, it will be seen, re identical with "king" and "queen"-post wooden trusses—but subseuently it was found out that these old lines of principle could be deviated

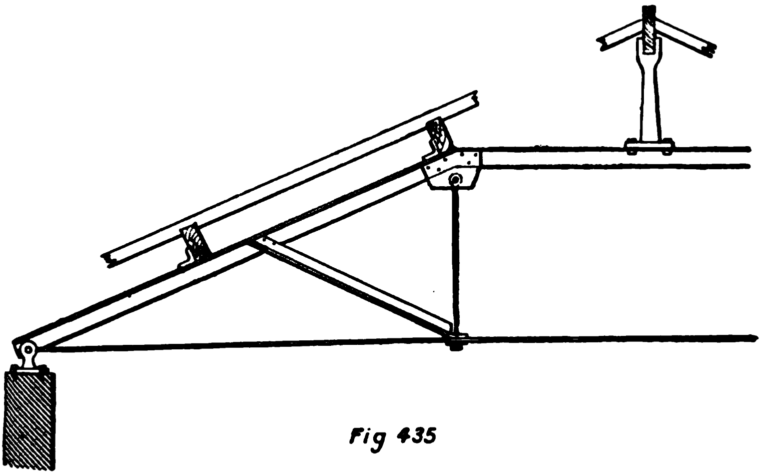


Fig 435

from with advantage, causing a saving of labour and material without any oss of strength whatever. Among the various novelties in form then and fterwards introduced were trusses similar to figs. 436 to 441; or they vere oftentimes made of circular form—*i.e.*, with a circular roof formed by

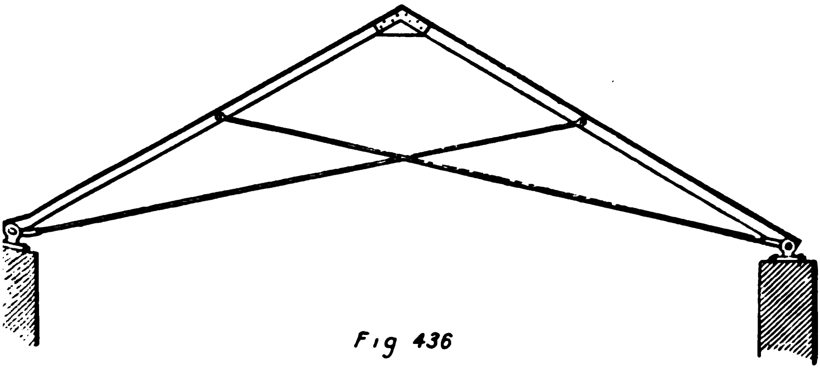


Fig 436

a circular principal rafter, the framing to support it being on lines following one or other of the triangular-shaped trusses hereinbefore illustrated.

Strains on Truss-members.—In the study of iron roofs it helps the student considerably to have a knowledge, however slight, of the different strains, whether of tension or compression, which the members are generally subjected to; and with that end in view the writer would suggest that the following simple comparison be employed to distinguish one from the other—viz., if a rope can be substituted for the piece of iron, then it may be taken for granted that that member is in *tension*; whereas, if such substitution cannot be made without detriment to the structure, it is in

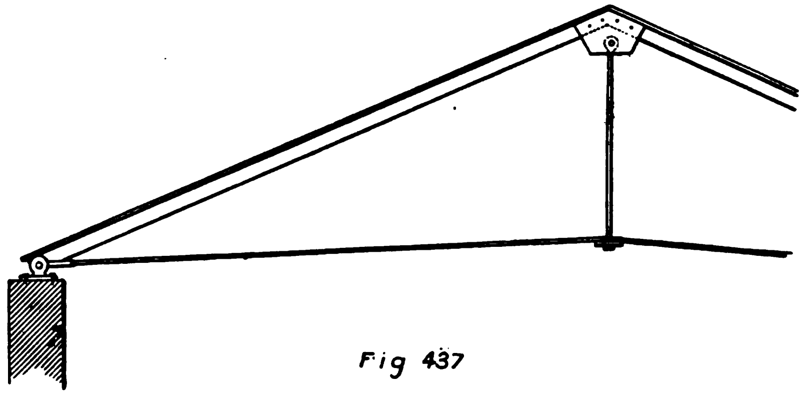


Fig 437

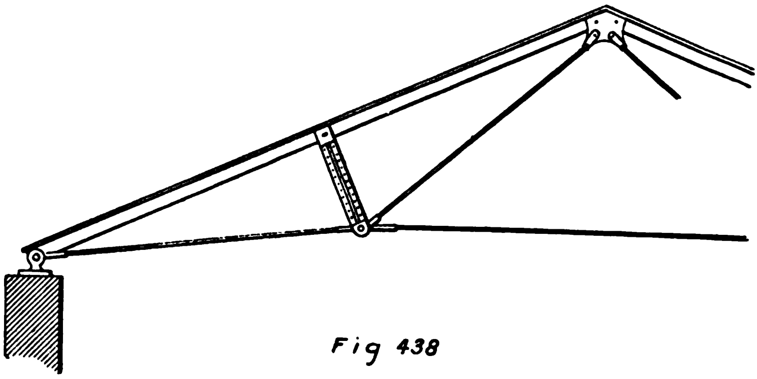


Fig 438

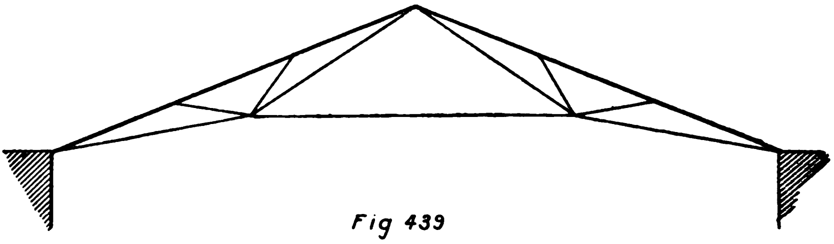


Fig 439

compression. This being ascertained, rods must be used for tension, and T's for compression, generally.

With this knowledge the student should be perfectly able to apply he principle of the following illustrated explanations of the ordinary joints to whatever ordinary roof is required. It would be an endless undertaking to point out the peculiarities of all joints of the many forms of iron roof-trusses, so that an exposition of the principles must suffice once for all.

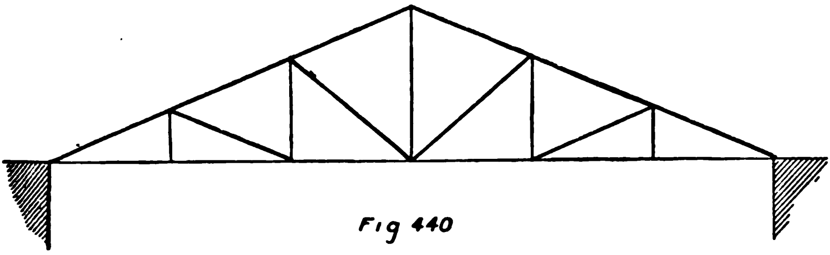


Fig 440

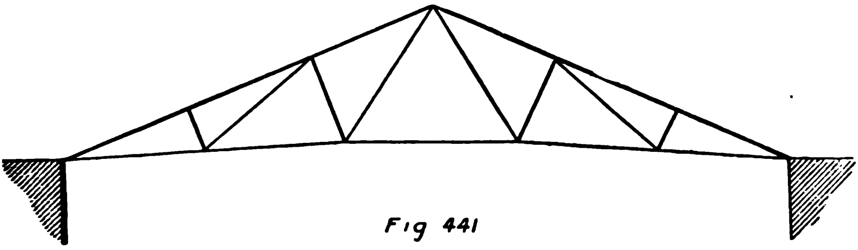
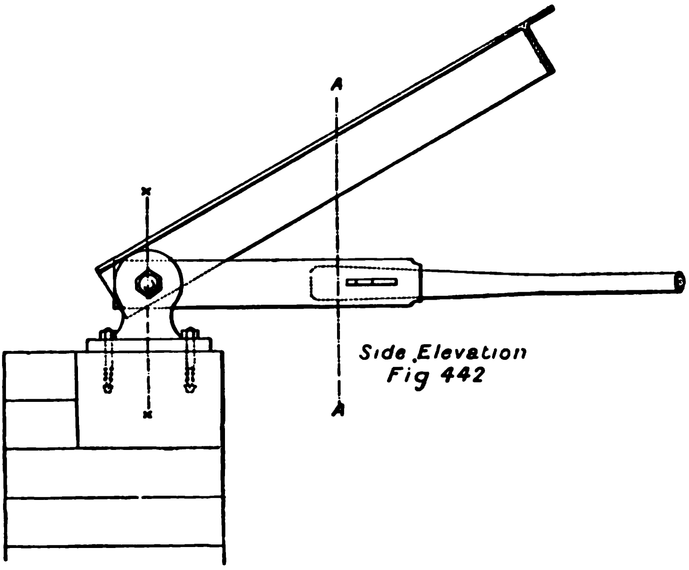
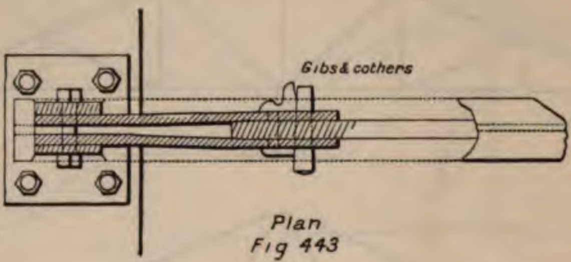


Fig 441



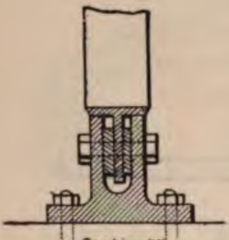
Side Elevation
Fig 442

Joints and Connections.—The foot of the truss is collected together and connected to the supports by means of a cast-iron shoe (as figs. 442 to 445), which, it will be seen, is a flat-bedded casting, with, as it were, two jambs, cheeks, or posts rising from it, and between these cheeks (as they may be called) is placed the web of the T-shaped rafters ; the remaining space, between the web and the two cheeks, being filled up with thin wrought-iron bars, which extend within the truss, and in their turn, figuratively speaking, grip the tie-rod.



Plan
Fig 443

Through these two cheeks, bars, and the web of the rafter, a pin or bolt is placed and screwed up at the outside, forming a complete connection and perfect attachment of all the members to the shoe—which is itself secured to the supports by *ragged* bolts, leaded into a hard stone pad built within the wall.



Section XX
End Elevation
Fig 444

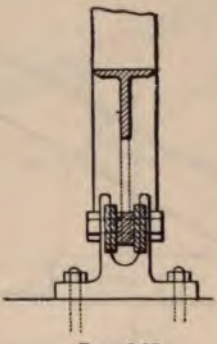


Fig 445
Section on A.A. Fig 12
& Elevation of shoe behind

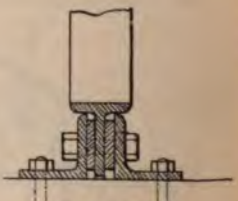


Fig 446

Sometimes, in common roofs, two angle-irons are bolted on each side of the wrought-iron bars enclosing the web of the rafter, being themselves secured to the pad-stones in the same manner as the cast-iron shoes (see fig. 446, which is a front sectional elevation). In large trusses, the contraction and expansion of the iron, as affected by the temperature, must be taken into consideration ; wherefore the shoes are made with a sort of ribbed base, which rests on oiled rollers, working on the bottom side of an iron box built into the wall to receive the shoe or chair, as it is sometimes called. This method, of course, supersedes the use of ragged bolts, and is shown in sectional elevation at fig. 447.

Where the shoe or chair has to be supported on columns, it is connected, as shown in fig. 448, to the abacus or square plate on the top of the cap of column.

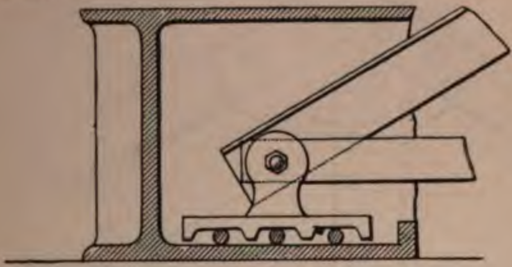


Fig 447

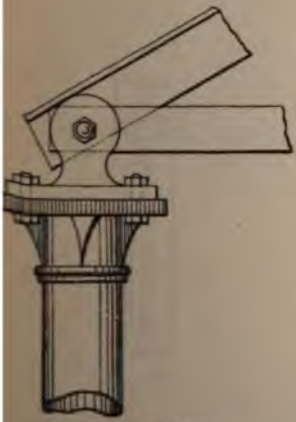


Fig 448

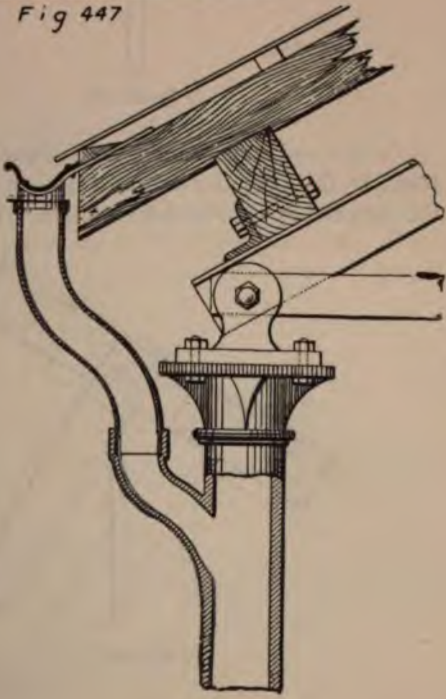


Fig 449

If there happens to be an outlet of an eaves-gutter next to a column n a roof of this description, the water must be made to run down the nside of the column as the downpipe, the water being conveyed to an nlet-hole specially cast on the column by means of a "swan-neck," as ig. 449.

The rafters at the apex and the suspension rod are connected together by thin cover plates on each side of the web of the rafters, gripping the suspension rod below the rafter apex, where there is a space, as fig. 450.

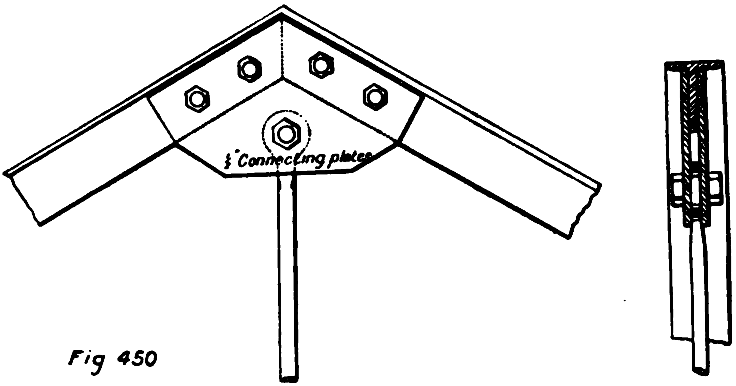
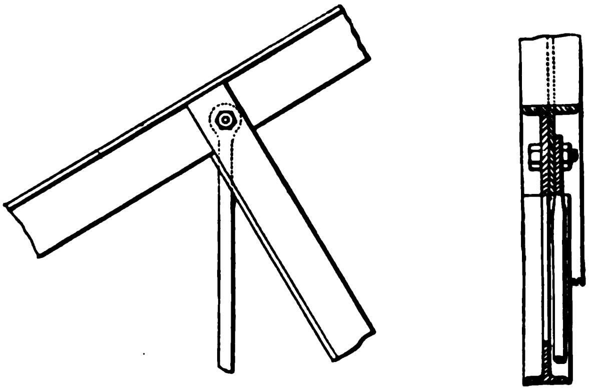


Fig 450

Elevation

Section

A strut and suspension rod are connected to the rafter by a joint, illustrated by fig. 451; the web of the strut being attached on one side, and the flattened eye of the rod the other. The three are connected together by a bolt, and the flange of the strut is cut off close up to the underside of the web of the T rafter.

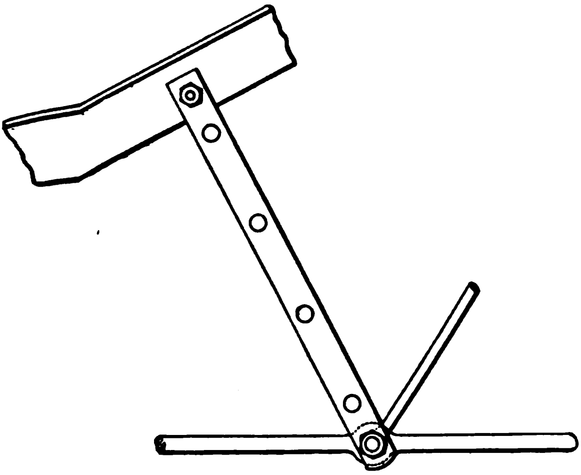


Elevation

Section

Fig 451

Struts, from their great tendency to bend, when in long lengths, under heavy weights, have often to be built up of various *blocked* members, as figs. 452 to 455, in lieu of plain T-iron, which is used under ordinary circumstances. They may be either straight or bulged, the latter being preferable, but more troublesome (*vide* figs. 453 and 454). The ends of the rods are forged out from the round, to grip the two plates of the strut enclosing the flattened tie-rod, as shown in the enlarged section (fig. 455).



Front Elevation
Fig 452

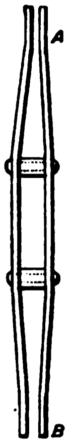


Fig 453

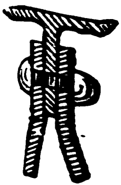


Fig 454

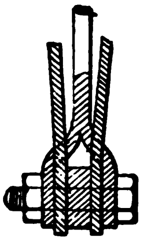


Fig 455

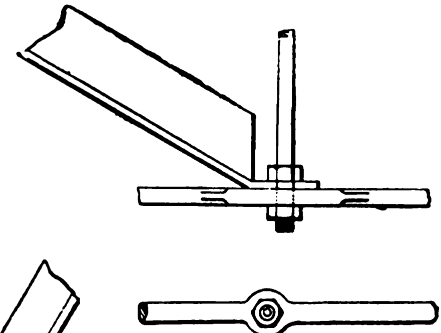


Fig 456

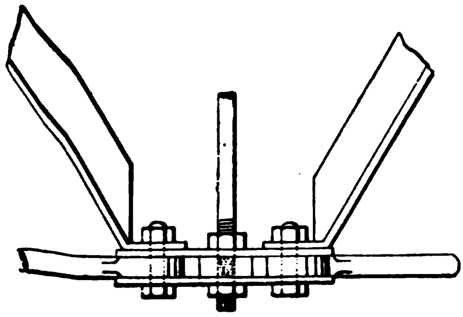


Fig 457

A single strut, of ordinary T-iron, is connected to the tie-rod, as in fig. 456; the web of the strut being cut off and the flange bent over the bulged tie-rod, the suspension rod going through both, and being bolted up underneath. If the flange of the strut is cut off at the top joint between the strut and the rafter, the web is cut off at the bottom joint between the strut and the tie-rod, and *vice versâ.*

The joint at the foot of the centre suspension rod and struts, when of T-iron, is as fig. 457, fig. 452 also applying to this joint, with a little modification, when the strut is built up. As it is usual to camber the tie-rods, they are made in two lengths, and connected at this joint as the illustration explains.

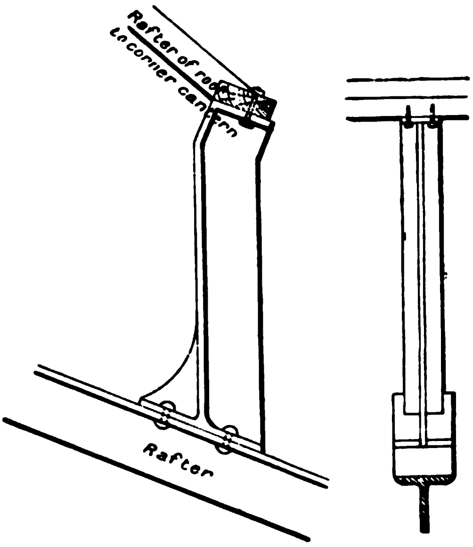


Fig 458

Louvres and *lanterns*, on iron roofs, are constructed by cast-iron supports, secured to the top of the T rafters to carry the roof framing, as fig. 458, the wall-plate being fixed by coach screws through holes drilled on the top of the casting, as shown in elevation.

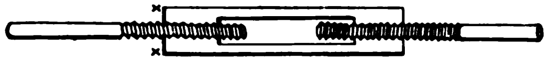


Fig 459

When tie and other rods have to be jointed in their length, they are treated as fig. 459, which illustrates a coupling-screw, X being a minus-thread—*i.e.*, within the circumference, and the other a plus-thread—*i.e.*, projecting beyond the circumference. It will be seen that the turning of the hexagonal coupler draws each rod inwards or pushes it outwards, the threads being different at each end—the one a right-handed, the other a left-handed screw.

Diagonal, or cross-ties, are used for tying several roof trusses together to resist a strong wind, driving at their end, and having a tendency to make them overturn. Fig. 460 illustrates their use, one end being fixed to the foot of one truss at X X, from which it runs up to the ridge of Z. Such cross-bracing is requisite for wood and iron roofs with gable ends alike.

Iron roof trusses are usually placed about 7 feet apart, the same distance generally being between the suspension rods, measured along the tie-rod, and also between the struts to the rafters.

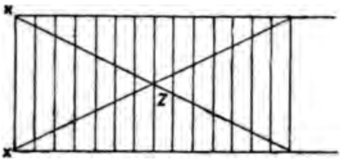


Fig 460

The rise of iron roofs (which are generally covered with light materials in weight) is from $\frac{1}{8}$ to $\frac{1}{4}$ of their span; the tie-rod cambering from $\frac{1}{40}$ to $\frac{1}{18}$ of its length.

Dimensions.—The following table gives the safe and economical sizes of the various members of strut and tie wrought-iron roof trusses, of different spans, spaced 6 feet 8 inches centre to centre :—

Span.	Diameter of parts of *Tie-rod.*	Diameter of *Suspension rods.*			Dimensions of	
		King.	*Queen.*	*Princess.*	*T struts.*	*T rafters.*
Feet.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
20	¾ and ⅝	¾	⅝	—	2 × 2 × ⅜	2½ × 2 × ⅜
25	1 and ⅞	⅞	¾	⅝	2 × 2 × ⅜	2¾ × 2½ × ⅜
30	1⅛ and 1	1	¾	⅝	2½ × 2½ × ⅜	2¾ × 2½ × ½
35	1¼ 1⅛ 1	1	¾	¾	2½ × 2½ × ⅜	3 × 2¾ × ½
40	1⅜ 1¼ 1⅛	1⅛	⅞	¾	2½ × 2½ × ⅝	3½ × 3 × ½
45	1⅜ 1¼ 1⅛	1¼	1	⅞	3 × 3 × ½	4 × 3¼ × ½
50	1½ 1⅜ 1¼	1¼	1	⅞	3 × 3 × ⅝	4 × 3½ × ⅝
55	1⅝ 1½ 1⅜	1⅜	1⅛	1	4 × 4 × ½	5 × 4½ × ⅝

CHAPTER XIV.

COVERINGS FOR ROOFS.

Lead Work—Lead on Roofs—Zinc Work—Zinc on Roofs—Slates—Forms of Slates—Fixing of Slates—Tiles—Fixing of Tiles—Special Forms of Tiles.

Lead Work.—Lead is a material of a soft, heavy, highly fusible, and extremely flexible nature, used as a covering to flat roofs, and as a means of rendering slated and tiled roofs watertight; being, on account of its flexibility, highly adapted for all angular and similar joints in roofs, where the brittle nature of tiles and slates renders them useless. It has no strength whatever, and is the product of an ore which is *smelted* down to a molten state, and rolled into large sheets, or made into pipes and cast-pigs which are beyond the province of this chapter.

The sheets may be either cast or milled, the former being heavier in weight, thicker, and harder; but, on account of its irregularity in thickness and liability to flaws and sandholes in the casting, it is of little service to the plumber, except in very heavy work and the covering of exceptional church roofs.

Milled lead is rolled out, as the name implies, into thinner sheets of a more uniform thickness and denser nature, and it is in this form that lead is mostly used by the builder or plumber for roof-coverings and similar work, in which it can be "bossed" up as required. Its quality is described by its weight per superficial foot, the qualities most used being 4, 5, 6, 7, and 8 lbs. per foot in weight; and, to give the student an approximate idea of its thickness, it may be mentioned that 7 lbs. milled sheet lead is a little under and 8 lbs. a little over $\frac{1}{8}$ inch in thickness.

Except in very exposed positions the following weights are suitable, and generally used for the nature of work specified: 4-lb. for soakers; 5-lb. for flashings; 6-lb. for valleys; and 7-lb. for gutters, flats, hips, and ridges.

It should always be borne in mind that the sun has great power over lead, drawing it away, as it were, so that leadwork should never be securely fixed, but always free to move. Before proceeding to enter fully into the details of the various positions in which lead is used it will be advantageous to enable the different parts to be identified on a roof plan.

Lead on Roofs.—Fig. 461 represents a plan of a roof, and will show most of the positions in which lead is used on a roof, the letters on the plan referring to the following members: A, a ridge; B, a hip; C, a valley; D, a flat; E and F, gutters between two roofs; G, gutters behind a parapet; H, a cesspool; L, a roll; M, a drip; N, a gutter behind a chimney; P, an apron in front of a chimney; Q, the parapet wall; R, the top of cornice; S, a gable where the flashings and secret gutter would be used; T, a step-flashing on the side of a chimney; V, junction of flat and roof; W, an iron eaves-gutter.

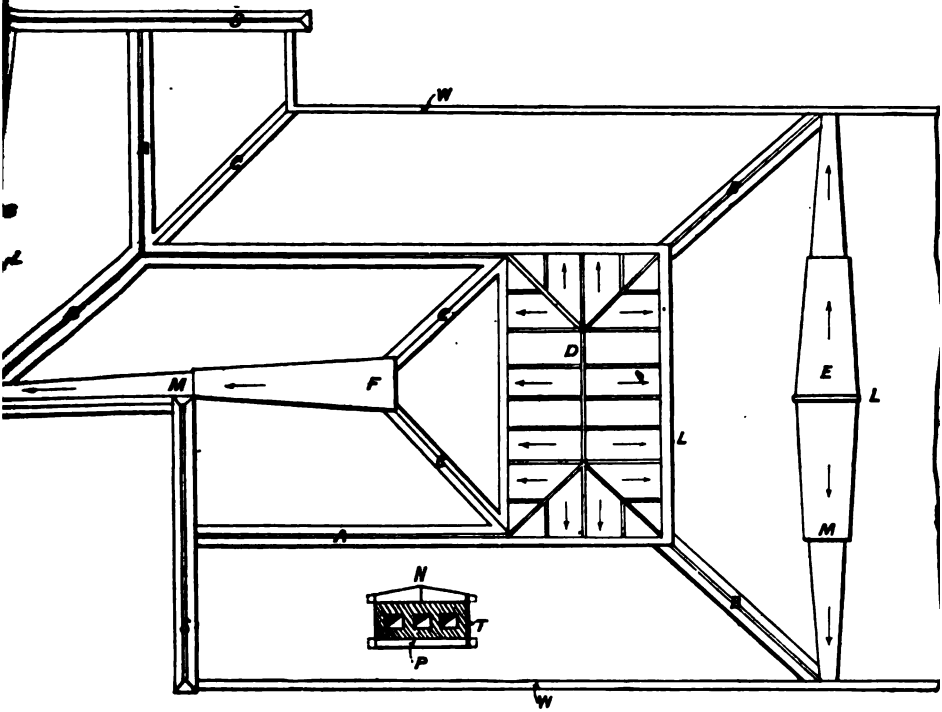


Fig 461

Following this key plan, we have, first, the *ridge* A, which is treated as fig. 462, a wood-roll 2½ inches in diameter being secured by double-shouldered spikes to the ordinary ridge as shown; or nailed to a bevelled fillet secured to the ordinary ridge, as fig. 463, the object of which is to enable the plumber to be the better able to dress the lead under the ro in order to form a key, so as to prevent the sun from drawing it off.

In practice, the bottom of the roll should be no less than 2 inche above the top of the ridge to allow for this key; and the wings or sides the lead covering should extend 7 inches down the roof over the slate The lead is put on in 7 or 8-feet lengths, with a 6-inch lap at the joint

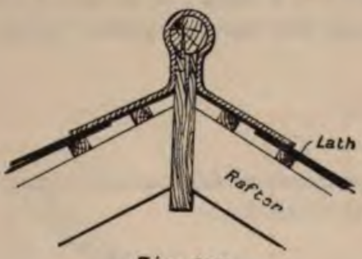


Fig 462

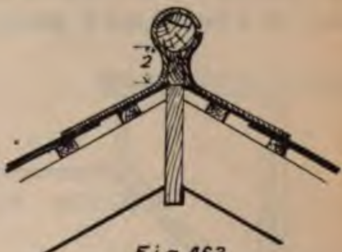


Fig 463

and fastened down on the top (so that it has freedom to move elsewhere by round-headed copper spikes, or by lead tags about 1½ inches wide fixed by copper nails, 2 or 3 feet apart, to the woodwork underneath, a fig. 464.

B. *Hips* are treated in section in a similar way to ridges, th difficulty at the junctions with the ridge being got over by the hips bein dressed down first, and the ridge lapping over, as fig. 465; and the foot

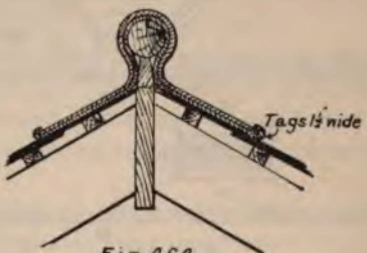


Fig 464

the hip is bossed, as shown at the foot of the same figure, the roll itself stopping several inches off the eaves, and being rounded off for the lead to be dressed over as illustrated.

C. *Valleys* are internal angles, as opposed to hips, which are external. Fig. 466 represents a section of a valley; 5 inches of lead should be visible from the edge of the slate to the centre or angle of the valley, to allow a person to walk up them without breaking slates, and the lead should go 6 inches under the slates, and be nailed by copper nails, always over the tilter, and just turned up the roof, as shown. They are put on in 7 or

-feet lengths, and, where a joint occurs, the bottom piece is copper-nailed inches under the upper piece, which is dressed over similarly to fig. 467. A saddle-piece is used at the top, next the ridge, just as for hips, the valley-piece going 6 inches under the saddle-piece.

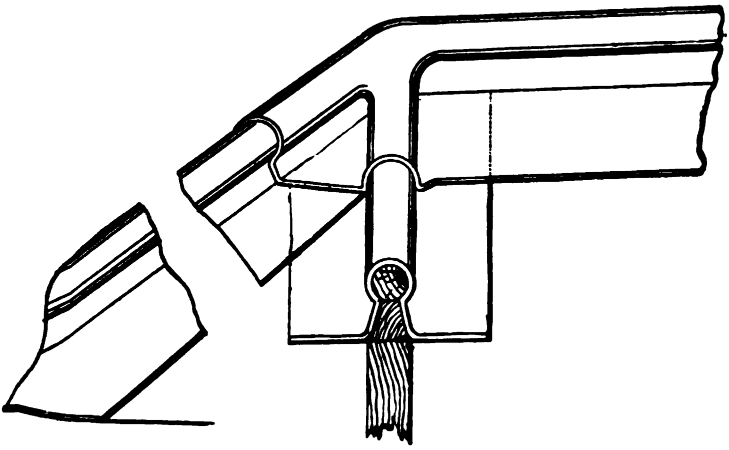


Fig 465

D. *Flats*, as the name implies, are roofs with small pitches which have to be covered with lead (or zinc), as slates and tiles are wholly unsuitable and ineffectual. The boards on which the lead is to be dressed should be laid "with the fall," so that there may be no projections and sharp edges across the fall to cause the lead to wear; and for the same reason they should be also of such thickness that there is no possibility of their warping.

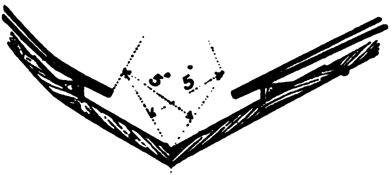


Fig 466

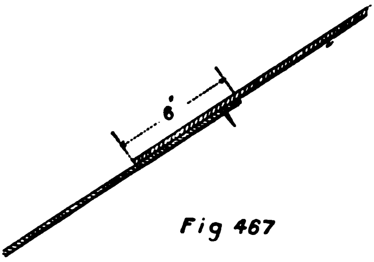


Fig 467

The boards being laid according to the above principle, and to a fall of 1½ inches to 2 inches in 10 feet, and as the lead should never be in more than 10-feet lengths at the outside, and that only in exceptional cases —7 or 8-feet lengths are the best, and also the most economical, as the lead sheets are only 7 feet 9 inches wide, sizes above that length having to be cut lengthwise—the rolls to joint it are fixed at certain distances apart, usually 2 feet 10½ inches from centre to centre, or about 32 inches apart, so arranged (for economy) that two widths can be cut without waste out of the width of a sheet 7 feet 9 inches wide; it is also unadvisable to have the lead in larger surfaces, in view of the sun's power over it.

These rolls, fixed at the above distances apart, are used as a basis for the joint, one side of the sheet of lead going over and being secured by copper nails to one roll as X, on fig. 468; and the other side is lapped to a distance of 1½ inches on the flat, over another sheet already treated as the first side. This, it will be seen, makes a complete covering, and allows the lead to expand, as it will be noticed that it is only fixed at one side, as X, the other being loose and dressed over the roll to keep it in position. The ridge and hips, on the flat shown in fig. 461, are treated in exactly the same manner; the mitres being dealt with as fig. 469, one sheet lapping over the complete joint, covering up the other different sheets in a manner similar to the sections on fig. 468. The ends of the rolls are bossed similarly to hips.

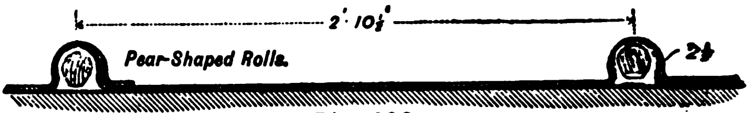


Fig 468

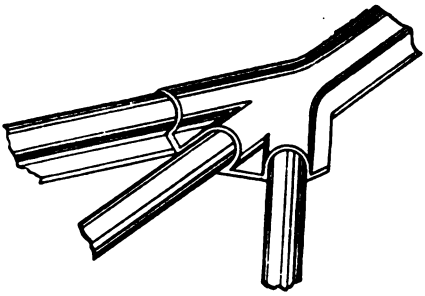


Fig 469

The nose, or eaves, of the flat, on to the roof, is worked as fig. 470, the under-piece (called an apron) being dressed and copper-nailed into a rounded rebate worked on the boards across their grain, so that the top piece of lead may not be tilted up by the under-piece.

E and F. *Gutters* between roofs and behind parapets, as G, are subject to similar rules to the last-named with regard to falls and the lengths of the sheets of lead between drips M, or drips and rolls L;

idths being regulated by the width of the gutters, which increase in in their ascent, as explained in the chapter devoted to "Carpentry."

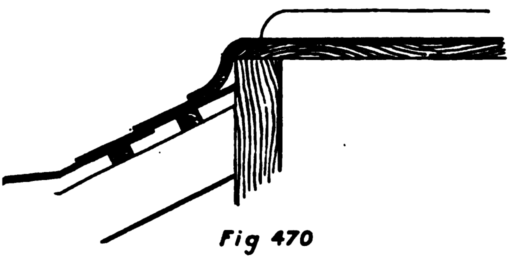


Fig 470

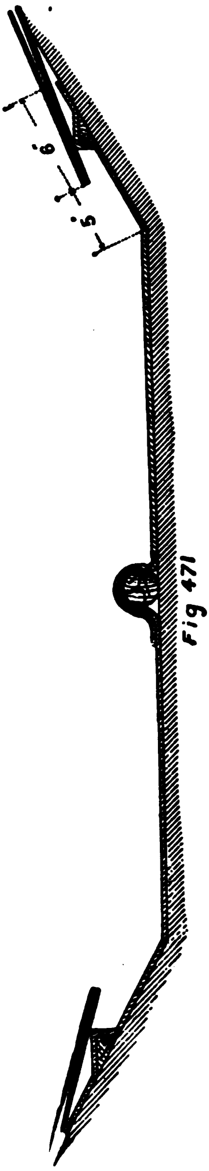


Fig 471

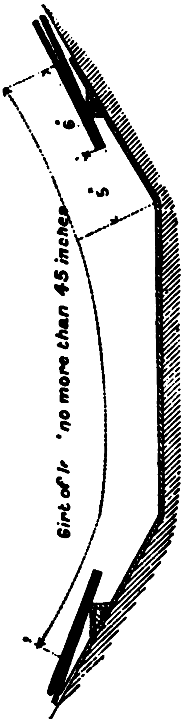


Fig 472

Fig. 471 represents a section of a gutter between two roofs, where the idth of gutter precludes the lead being used in one width, as fig. 472.

It should be here pointed out that a gutter should always be 9 inches wide on the flat at its lowest point, increasing in width as it rises.

G and N. Fig. 473 is a section of a gutter behind a parapet wall or chimney, the lead being turned 4 inches up the wall at X, and covered over by a *cover-flashing* 5 inches wide, wedged with oak or lead wedges into a brick joint or stone groove. It will be noticed that the lead goes 6 inches under the slates; but this should be increased to 9 inches in flat roofs, where snow would lodge, as the flatter the pitch the less height there is between the top of the gutter and the top of the lead, as fig. 474, for the snow to lie in.

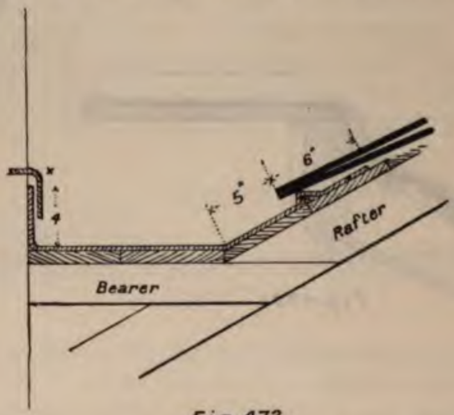


Fig 473

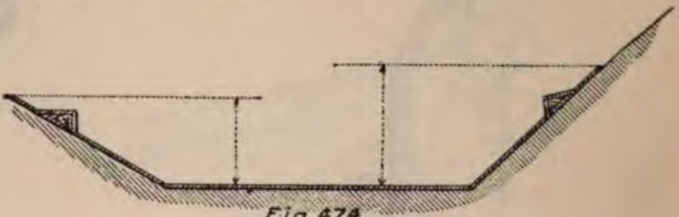


Fig 474

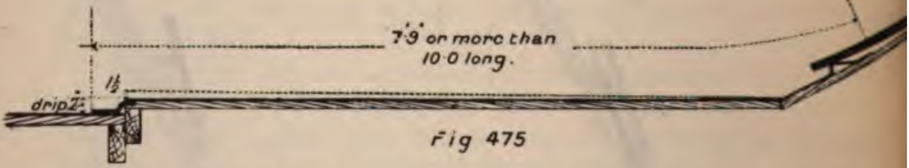


Fig 475

Rolls are used across gutters falling both ways to joint the lead and to divide them as a ridge does a pitched roof.

Fig. 475 gives a longitudinal section of a gutter, starting from a pitched roof, downwards through one drip, which may be treated either as figs. 476, 477, or 478.

H. *Cesspools* are boxes formed at the bottom of gutters, to collect the water previous to discharging it through a pipe from a hole in the bottom to the head or downpipe. The best way to treat them is as shown by fig. 479, which needs no explanation; except to say that where the angles, sides, and bottom of the box cannot be bossed in one piece they must be *soldered—i.e.*, copper-nailed and covered with solder (a composition of lead and tin) laid on while hot to adhere to and connect the adjoining lead.

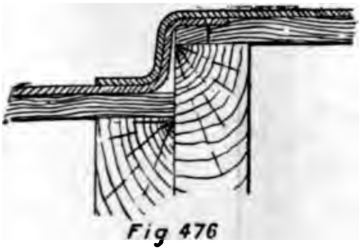


Fig 476

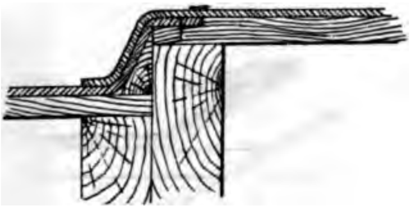


Fig 477

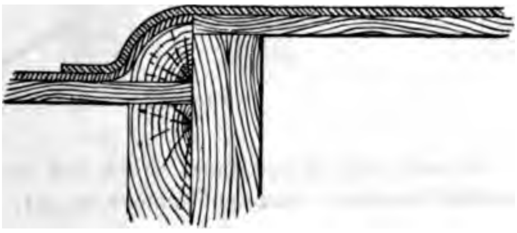


Fig 478

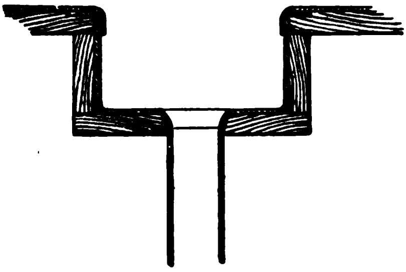


Fig 479

N and P, a gutter and an apron. Fig. 480 gives a section through a chimney, showing the gutter at the back, and an apron flashing in the front, both of which should be not less than 6 inches longer than the width of the chimney, at each end, so that they can be laid on one slate, and covered by another to make a water-tight joint, as fig. 481.

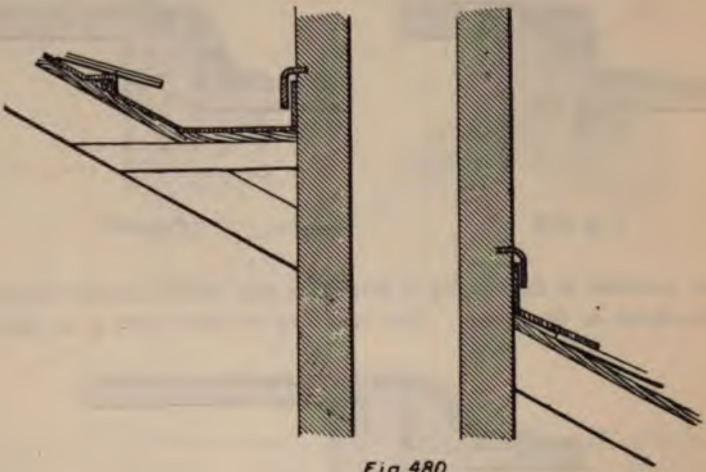


Fig 480

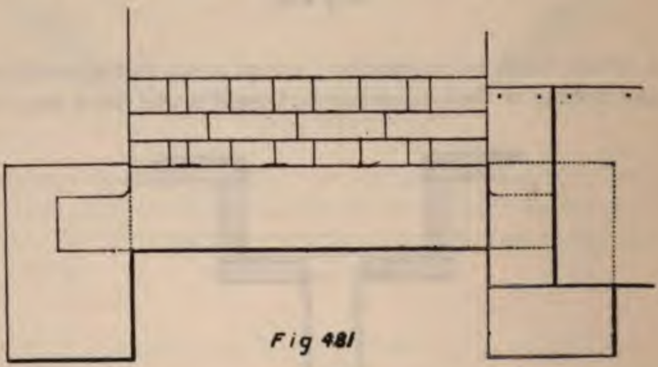


Fig 481

The elevation of the side of a chimney, showing a *step flashing*, is as fig. 482 These step flashings are more ornamental than the plain cover flashing, fig. 483; and they are either cut out in one piece 5 inches wide to work in with the brick joints as fig. 484, or each is put on as a separate step, as fig. 485; their object, and that of other flashings, being to cover the up turns of gutters, as shown by X, on fig. 473; or of *soakers*, as

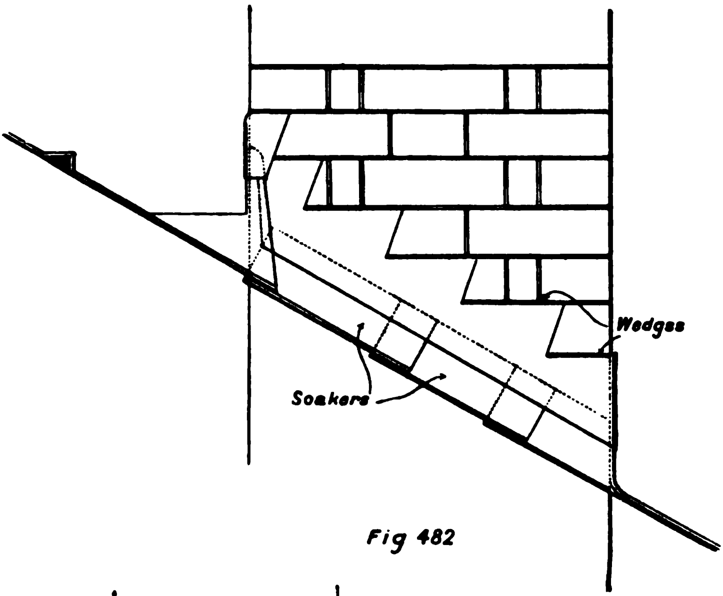


Fig 482

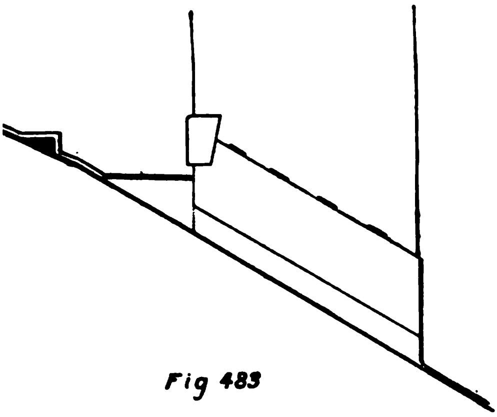


Fig 483

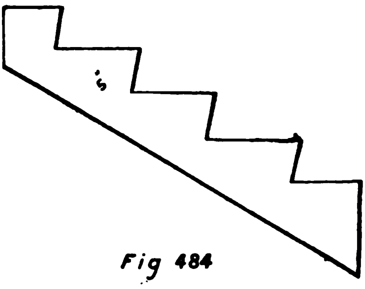


Fig 484

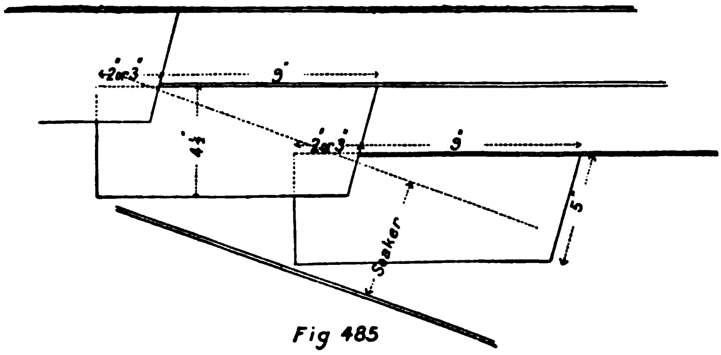


Fig 485

fig. 482; a *soaker* being a small piece of lead the length of the gauge and lap of a slate or tile (as explained in the next chapter), by 6 or 7 inches wide, 3 of which go on and under the slates, and the remaining 4 are turned up the chimney or the gable, as fig. 486.

Flashings must always lap at the angles round a chimney—*i.e.*, the step or side flashing must turn round the angle, on to and over the apron; and the cover flashing of the gutter must do the same to the step or side flashings, as shown. *Secret gutters* are sometimes used, in lieu of *soakers*, up gables covered with copings, as fig. 487 in section.

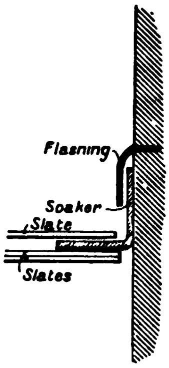


Fig 486

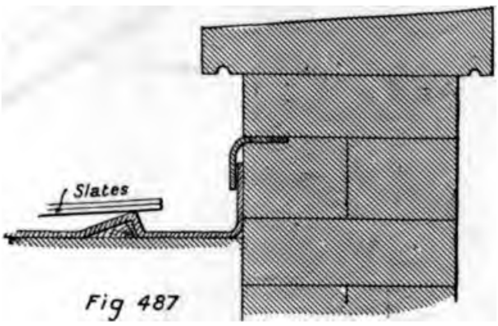


Fig 487

A *tingle*, as fig. 488, is a substitute for wood-rolls, though little used.

A *welt*, as fig. 489, is a folding of lead used to joint lead, where rolls are not used, and it is especially suitable for vertical lead-work, the under-piece being copper-nailed, as shown.

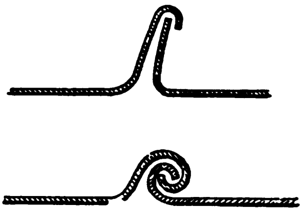


Fig 488

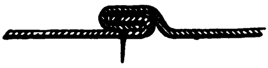


Fig 489

Soldered or lead dots are used for securing lead on vertical or flat surfaces, where neither rolls, tingles, nor welts can be used, the mode of procedure being as follows: a hole is scooped out of the boards, the lead dressed in and screwed down, and the hollow is afterwards filled up and rounded over with solder, as fig. 490.

A *raglet* is a groove cut in masonry to receive the turn in of lead; and when this is done on the top of blocking course, and over flat surfaces, the lead is "burnt in"—*i.e.*, the "turned in" is secured by running molten lead into the groove or raglet.

A *bottle-nosed drop* is as fig. 491, from which it will be seen that the upper board projects sufficiently to protect the turn-up of the lower gutter and the top gutter is dressed over so as to form an apron. This mode has the disadvantage of the lead apron being easily turned up, an objection which is obviated by treating the drips as in figs. 476, 477 and 478.

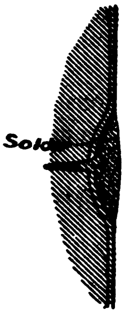


Fig 490

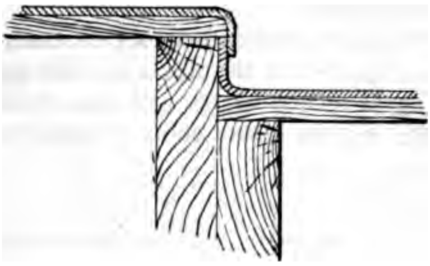


Fig 491

Zinc Work.—Zinc is a very thin, light metal, used for roof-covering on a cheaper scale, being about one-third of the cost of lead. It is used for gutters, valleys, soakers, and flashings, in common work, in like manner to lead; but it is chiefly as a cheap covering to flat and iron roofs of stations and other large erections that it is valued and mostly used. Zinc is very fusible and tough, and can be easily bent backwards and forwards without cracking. Moist air, when it does not contain acid, forms a coating over it of oxide, which protects it; but sea and town atmospheres, tainted with acid, soon destroy it.

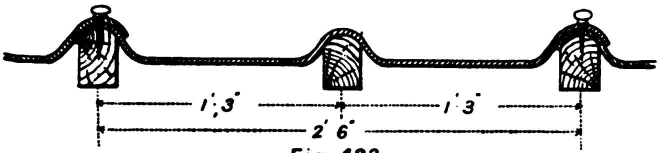


Fig 492

Zinc is sold in sheets, the qualities of which are distinguished by *gauges*, varying from 1 to 26, and weighing from 1 to 60 ounces per foot, superficial. The qualities most used for building purposes are from 14 to 20 gauge; more generally the former, which weighs about 18 ounces per superficial foot.

Zinc on Roofs.—The simplest form in which zinc is used as a roof-covering is in corrugated sheets, about 30 inches wide and 7 feet long, the ordinary kind having corrugations every 3 or 4 inches. The sheets are laid from purlin to purlin, placed about 30 inches apart, for the purpose, lapped on to the corrugations at the longitudinal joints, as well as at the transverse joints, up the roof; and they are secured to the woodwork by round-headed screws with washers, the joints being connected by very small bolts.

The Italian corrugated zinc roof has much wider corrugations—namely, 15 inches apart—and the sheets are laid over rafters with rounded tops, appearing in section as fig. 492, from which it will be seen they lap alternately over the rafters, and are secured by mushroom-headed screws to the same rafters. Fig. 493 is a representation of Braby's *Italian* pattern.

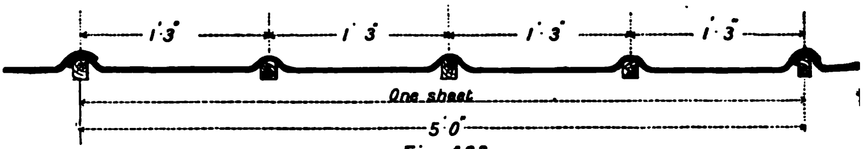


Fig 493

Flats are covered by zinc, as illustrated by fig. 494, in which the expansion and contraction (which is greater in zinc than in lead) is provided for. No solder nor external fastenings whatever should be used; and, to ensure the best work, the zinc should be laid by experienced men only.

Zinc is, of course, laid on boarded roofs with 2½-inch drips, to joint the zinc lengthwise, which is treated as figs. 495 and 496, shown in section and elevation; and these drips should be at intervals of every 7 feet 6 inches, or thereabouts. Roofs with falls exceeding 12 inches in 8 feet need no drips, and the sheets are jointed by folds, as fig. 497. The wood rolls, not rounded as for lead, are fixed, as in fig. 498, 2 feet 10½ inches centre to centre, so that the zinc between them may be in one sheet, the joints being made in the rolls, as in figs. 499 and 500.

The ends at the bottom and top of capping are treated as figs. 501 and 502, and the flashings against walls are dealt with as in fig. 503.

Zinc may be treated in a very ornamental manner, as well as used for ordinary work and flat roofs. The embossed work on the Hotel Metropole,

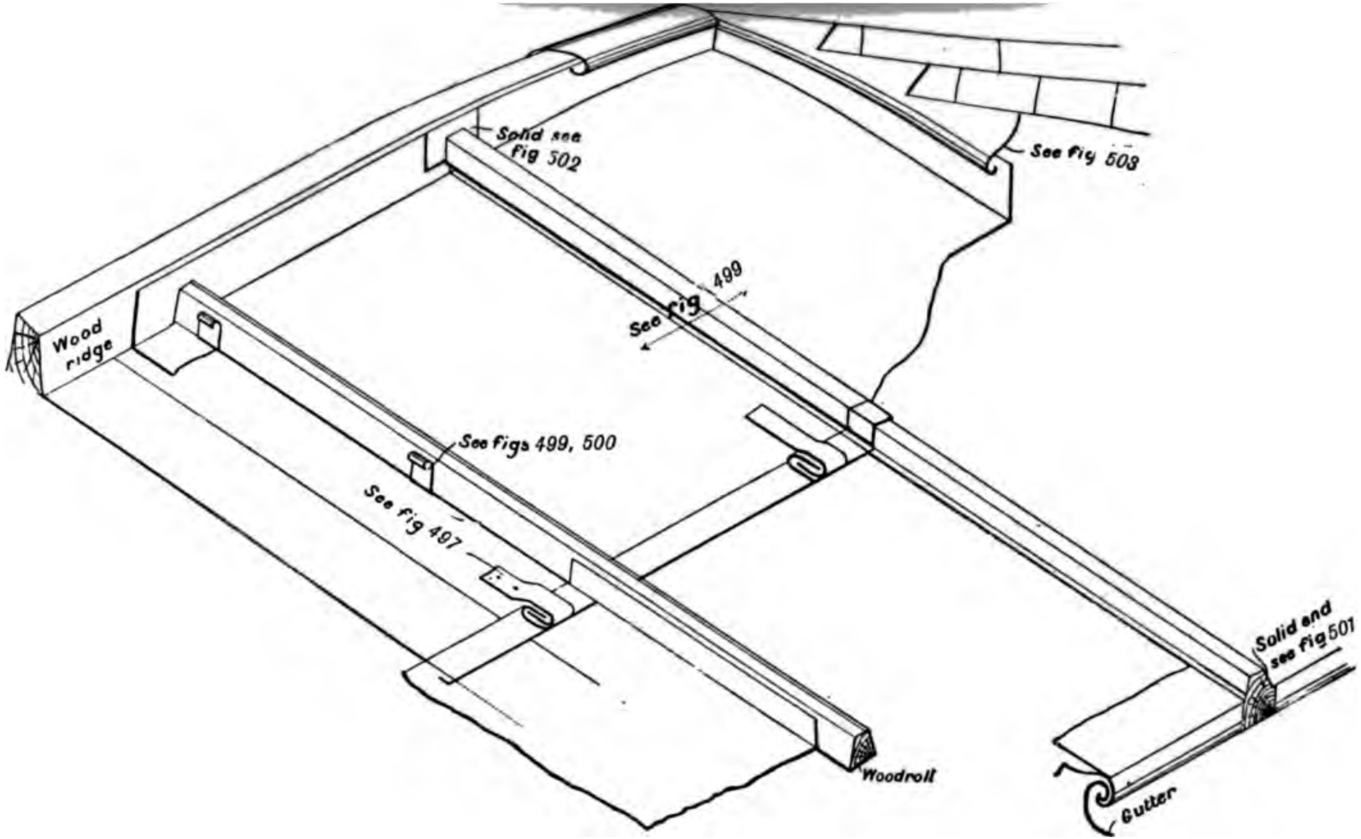

Solid see
Fig 502
See fig 508
Wood
ridge
See fig 499
See figs 499, 500
See fig 497
Woodroll
Solid end
see fig 501
Gutter

Fig 494

London, was executed in zinc by Messrs. Braby; and it should be pointed out that the system of zinc roofing here explained is as advised by

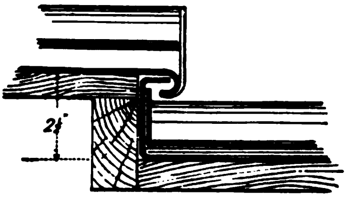


Fig 495

that firm, who are the English agents for the "Vieille Montagne," the best and purest zinc in the market.

Slates.—Of the two materials—slates and tiles—generally used in

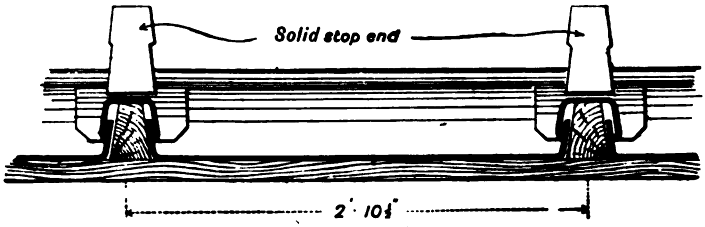


Fig 496

towns for roof-coverings, slates are the more common, being cheaper and better suited to the flatter kind of pitched roofs (of about 30 degrees)

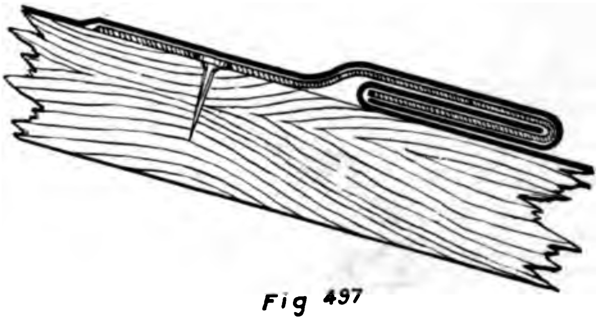


Fig 497

which are less expensive than the steep ones. Slates are the production of an argillaceous or clay-formed rock, so fine-grained and compact that it splits readily into extraordinarily thin slabs of various sizes, which are formed into slates for roof-coverings, while the greater thicknesses are converted into shelving and slabbing for other purposes.

A *good* slate should be hard and yet tough, of very fine grain and

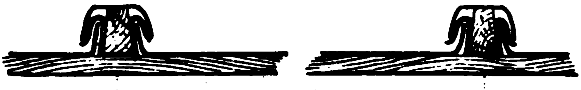


Fig 498

niform colour, thin and very non-absorbent, so much so that a good dry ate, after standing 24 hours in water halfway up its height, should not ve drawn up and absorbed any moisture above the water-line. Another

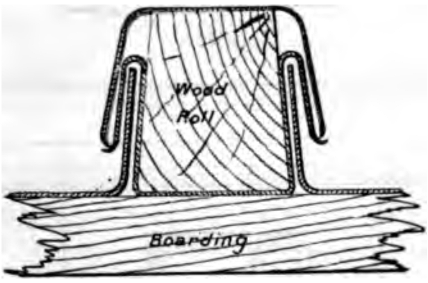


Fig 499

of good quality is to be able to breathe on the slate without bringing any clayey odour, which would be a sign that it will not weather.

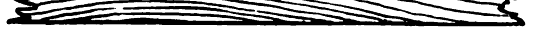


Fig 500

Wales and Westmoreland produce most of the slates used in this country, the latter being of a green colour—thicker, rougher, and much heavier than the Welsh. The latter are mostly of the same good quality, and remarkable for their thinness and smoothness, the best being from Penrhyn and Port Dinworic, the colours of which are alike. Of the many varieties the chief are distinguished by their colour. A Bangor slate is of a purple colour, while a Penrhyn slate may be either blue, purple, or green. Portmadoc produces a blue slate, and Whitland Abbey those of a green colour, which are thicker and softer than the other kinds.

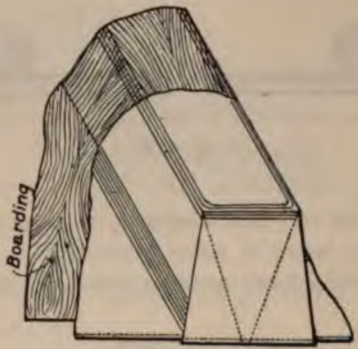


Fig 501

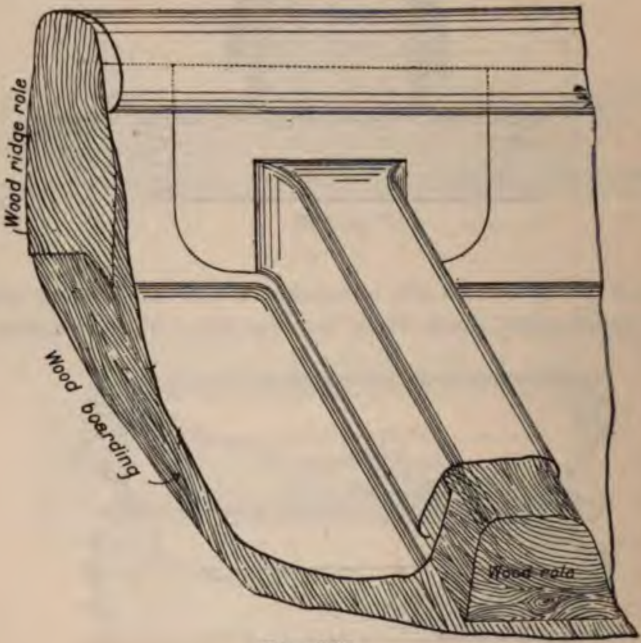


Fig 502

Stone slates are found at Colley Weston and Naunton, while many of the Yorkshire stones can be split fine enough for roofing purposes. A stone slate is a non-conductor of heat, while the ordinary kind of slate is a good conductor of heat.

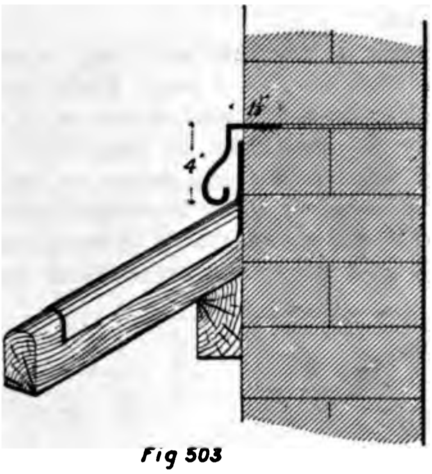


Fig 503

Forms of Slates.—The chief sizes in use (with their names) are as follows:—

Imperials .	. 30	inches long	by	24	inches.
Empresses .	. 26	"	"	15	"
Princesses .	. 24	"	"	14	"
Duchesses .	. 24	"	"	12	"
Marchionesses	. 22	"	"	11 or 12	"
Countesses	. 20	"	"	10	"
Viscountesses	. 18	"	"	10	"
Ladies .	. 16 or 14	"	"	10 or 8	"
Doubles .	. 13	"	"	10 or 7	"
Smalls .	. .	. .	.	below the latter.	

Fixing of Slates.—Slates are fixed, by two nails each, to the roof boardings, or to the longitudinal strips of wood (called *laths* or *battens*) running along the roof across the rafters. Of the two the latter is preferable to the boarding. The nails are either of galvanized iron, zinc, or copper.

The *back* of a slate is its upper surface or face, while the underside is called its *bed*. The *head* is, of course, its upper and the *tail* its lower edge. That part of the slate which is visible, when fixed on the roof, is called the *margin*, its depth being called the *gauge*.

Lap.—The *lap* of a slate is the distance that the top slate projects or laps over the second one beneath it (as fig. 504); and this word is used in conjunction with the name of the slates, of course, to denote the kind of work which is required to be done.

Thus we specify that Duchess or Countess slates are to be used, *laid to a 2½ or 3-inch "lap."*

Gauge.—Sometimes, however, the word *gauge* is used for the same object; as *laid to such and such a gauge*, which depends on the lap, though more chiefly on the size or kind of slate to be used. Given the lap and the name or size of the slates, the gauge can be found by calculation—*i.e.*, from the length of the slate deduct the lap, and half the remainder (because the slates are in two thicknesses) will be the gauge. In laying slates to a specification calling for "Countess slates laid to a 2½-inch lap," for instance, the first thing a practical man—not having the gauge at his fingers' end, as it were—would do, would be to calculate the "gauge." Thus: From 20 inches (the length of a Countess slate) deduct 2½ inches = 17½; half of that difference will be the gauge—*i.e.*, 8¾ inches. This last-named figure is the guide by which the slater "holes" his slates for the nails, and fixes his battens to the rafters, or marks his line for the nailing along the boarding. Good work, in slating, should have the tails of all slates perfectly horizontal, and the vertical alternate joints ranging in straight lines from eaves to ridge.

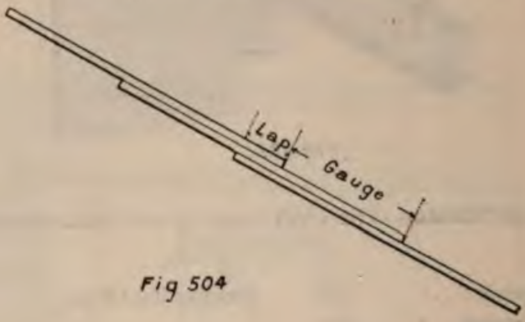


Fig 504

The first proceeding of a slater is to square three sides of the slates, the head being left rough, and then to hole them for the nails, which may be done either at the head or in the centre. When nailed at the head, the two nail-holes are pierced at a distance of about 1 inch downwards from the head, so that the tail of the second slate, when laid on above it, covers their position by 2 or 3 inches, which is the difference between two gauges and the length of the slate, less the distance the nail-holes are pierced from the head of the slate.

Centre-nailed slates do not have their holes exactly in the centre, but at the distance of the sum of the gauge and lap above the tail. Thus, the oles of Countess slates laid to a 3-inch lap would be: 8½ inches (the auge) plus 3 inches (the lap) = 11½ inches, above the tail, or thereabouts; o that the nails may clear or miss the head of the slate below.

Centre-nailed slates resist high winds very much better.

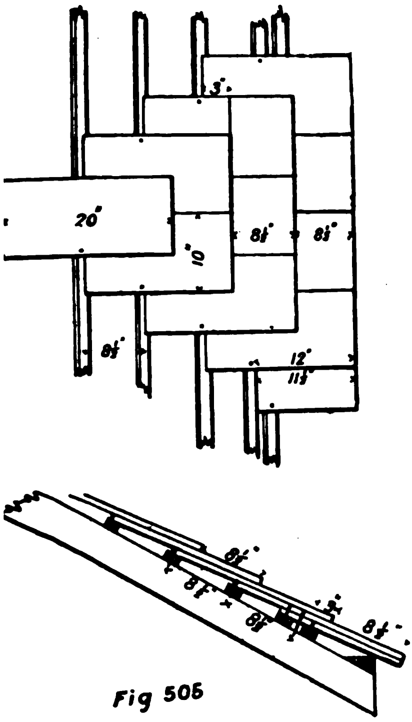


Fig 505

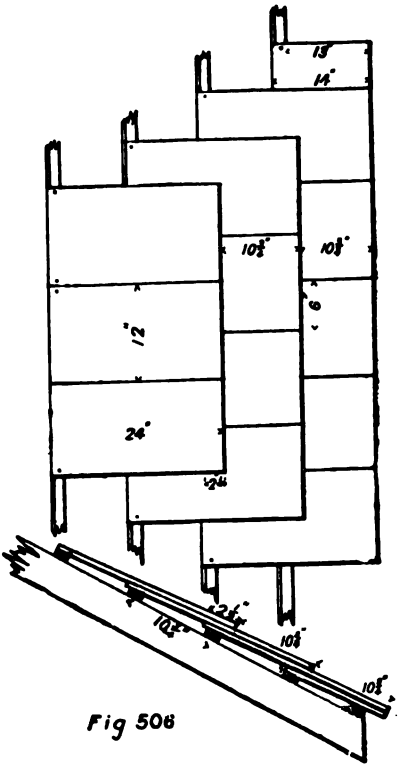


Fig 506

Fig. 505 gives a section and plan of *Countess* slates laid to a 3-inch lap and centre-nailed; while fig. 506 gives the same particulars of *Duchess* slates "laid to a 2½-inch lap and top-nailed"; and fig. 507 those of 16 × 8 inches *Ladies'* laid to a 6½-inch gauge and nailed at head.

From the above sketches it will be noticed that there is a different-sized slate at the bottom (at the eaves), shown by dotted lines; this is called *double eaves*, and its length is a little more than the sum of the lap and gauge, so as to allow for the nail-hold above. It should also be pointed out that, in centre-nailed slates, this involves the placing of two battens together at the bottom for eaves, whence, it should be noted, all slating starts, and is worked or laid in courses upwards.

Slates are bonded by *half-bond*, as the plans indicate, this necessitating a half-slate at the gables, etc.

Ridges have also a *double* course at the top, as fig. 508, surmo by either a plain ridge, as fig. 509; slate ridge and roll, as fig. or ridge-roll and crest, as fig. 510.

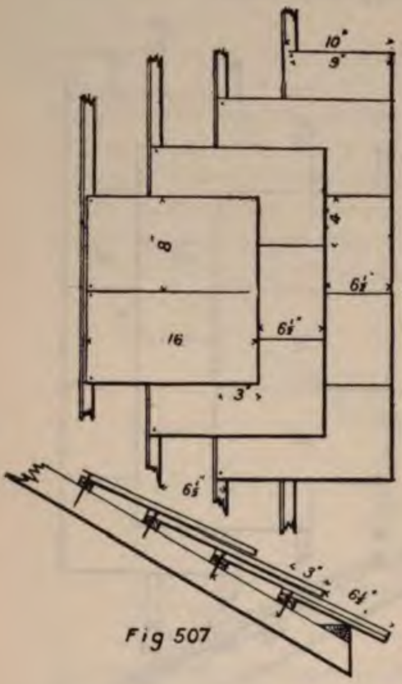


Fig 507

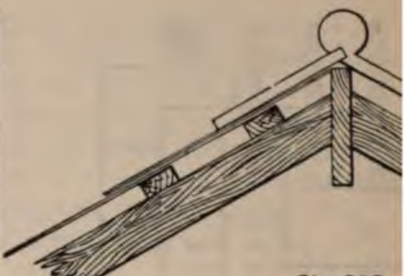


Fig 508

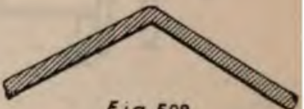


Fig 509

Torching is the pointing of the underside of slates with hair m used to stop the driving of snow.

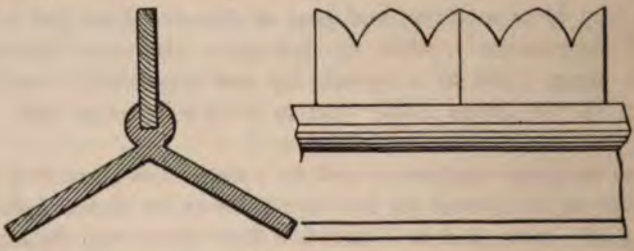


Fig 510

Full torching is the filling up of the space between battens mortar on the underside.

Shouldering is bedding the heads in mortar to tighten the nail and prevent the wind penetrating.

Rendering is the filling up of the space between battens or boarding to bed the slates down.

Open slating is used for open sheds and inferior work, to save slates, each slate being from 1½ to 4 inches apart, instead of butting up to each other in the courses.

Bedding is the setting in mortar of the top of the bed of one slate or tile on the back of the one beneath it.

Cement-filleting, an inferior substitute for lead or zinc soaker flashings, is the filling up with cement-mortar of the angles on roofs where they abut up to vertical parts, such as dormers, gables, chimneys, and other roofs, so as to prevent the damp running down the walls at the edge of the slates.

Verge-pointing is the pointing up of the sides of the slates running up gables over which they project.

Slates may be cut or laid to patterns, in order to give the roof a more ornamental appearance; but such alterations must not interfere with either lap or bond.

Tiles.—Tiles, as compared with slates, are a more expensive roof-covering material, not only from their composition and manufacture, but also on account of the extra trouble and battens they require for their smaller size. They also require that the roofs be of a steeper pitch, and no less than 45 degrees rise from the horizon, for the reason that any less pitch is subject to the liability of making the tiles absorb the rain instead of throwing it off. Again, the roofs for tile-coverings must be constructed of greater dimensions and strength, on account of the greater weight of the tiles, as compared with slates.

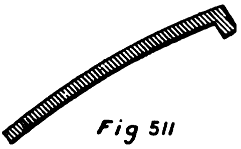


Fig 511

Against these disadvantages of tiles must be set their greater ornamental appearance, and their action as non-conductors of heat, and also their colour; these are all great considerations in their favour, even although they are sometimes, when absorbent, apt to hold the wet.

Tiles are made of a strong clay which has been specially mellowed, and beaten when half dry to prevent warping, and they are all of one size, 10½ inches long, 6¼ inches wide, with 2 nibs or projections at the shoulder or top edge, on the underside or bed, as fig. 511, to hold them up over the battens, and they should be curved slightly, to make them fit over each other the better.

There are several kinds of tiles for roofing besides the plain tiles, but they are all made out of the same material. A good tile should be hard, well burnt, well shaped, non-absorbent, of good colour, and with a glazed or vitrified face to prevent vegetation. The best tiles are made at Ruabc in Wales, though they are also largely made at Broseley and Madel Wood, in Staffordshire. They can be of innumerable colours, from red blue and yellow.

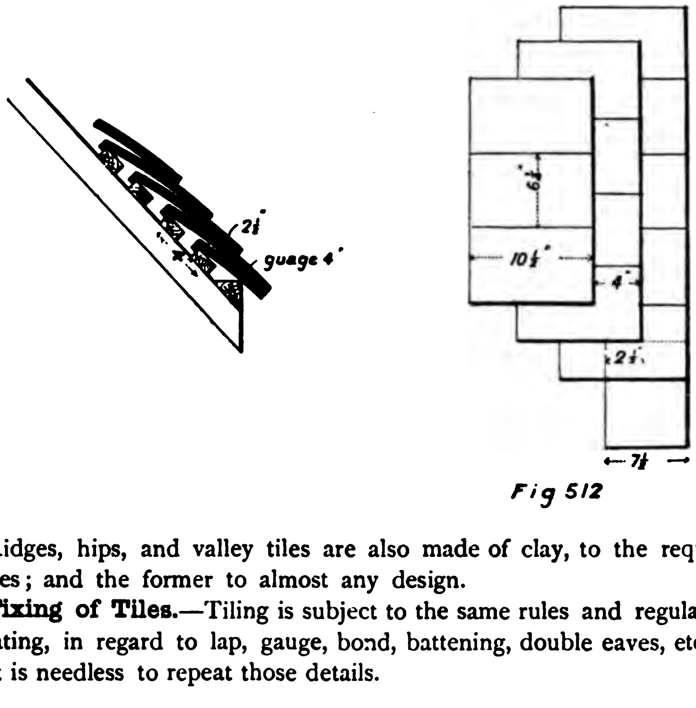


Fig 512

Ridges, hips, and valley tiles are also made of clay, to the requir pitches; and the former to almost any design.

Fixing of Tiles.—Tiling is subject to the same rules and regulatic as slating, in regard to lap, gauge, bond, battening, double eaves, etc., hat it is needless to repeat those details.

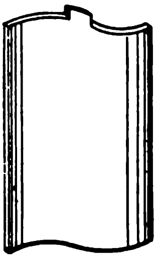


Fig 513

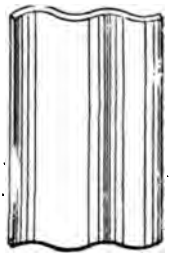


Fig 514

Fig. 512 is a plan and section of a few courses of plain tiling laid tc 2½-inch lap or 4-inch gauge. The tiles are generally secured merely by t lugs over the battens; but in very exposed positions they are sometin nailed, though this is very expensive, besides which the tiles must be ma with holes for that purpose, in the process of manufacture. Special ti are made for double eaves and ridges, to save cutting; and "tile and halfs" for gable ends, where, for purposes of bond, half-tiles would otherwise have to be used; and these being only 3½ inches wide, they would make very imperfect work, which is obviated by the use of "tile and half."

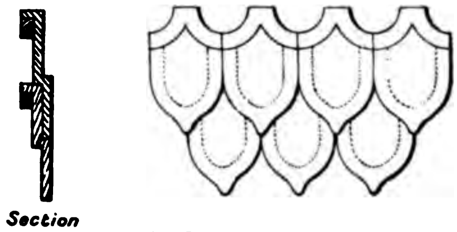


Fig 515

Special Forms of Tiles.—*Pantiles* are peculiar-shaped tiles, used in some parts of the country for roofs, but now only for common work. Fig. 513 is an illustration of one tile.

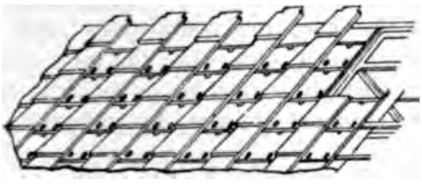


Fig 516

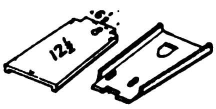


Fig 517

Corrugated tiles are similar to the last, but with more hollows or corrugations, as fig. 514.

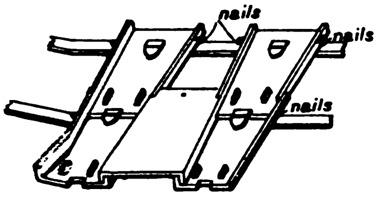


Fig 518

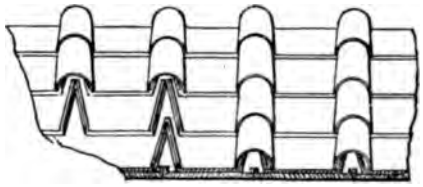


Fig 519

Wade and Cherry's are a patent tile of ornamental appearance, similar to fig. 515, rebated at the head, on the top side, and on the underside at the tail.

Taylor's patent tiling, as figs. 516, 517, and 518, consists of channel and capping tiles of special patterns, which fit over one another in alternate rows, from eaves to ridge, as shown. It should be noted that the same tile can be used as channel or capping tile by being reversed. Th have a very novel and pleasing ornamental appearance.

Italian tiles are illustrated by figs. 519 and 520, which explain the selves, and give an idea of their effective appearance in work; though will be seen that they are anything but well adapted to our sno climate.

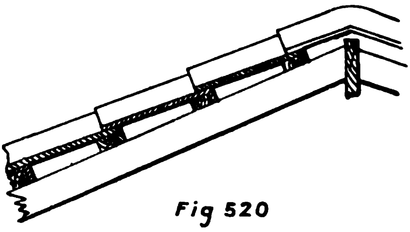


Fig 520

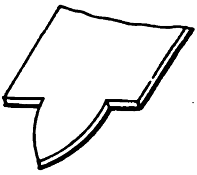


Fig 521

The plain tiles are often banded with ornamental tiles, as fig. 5 which break the monotony of a plain-tiled roof considerably; and th bands are sometimes laid in blue-coloured tiles, while the plain are r and *vice versâ*; but this is unadvisable, on account of the different nat and properties of the different varieties of tiles to withstand frost, etc.

CHAPTER XV.

FIREPROOF FLOORS.

Essentials of Fireproof Construction—Brick Arches—Concrete Floors—Special Systems.

Essentials of Fireproof Construction.—The highly inflammable nature of wood as a material used in the construction of floors, and the risk to life which it entails, has of late years received particular attention from the architectural and building world; the object of course being to design a floor which can be said to be entirely free from inflammable material, and proof against the attacks of fire in all its varied forms.

Wood has naturally been shunned—except, of course, as a covering, for the sake of comfort—while stone is known to be a most treacherous material under the influence of heat, as it will crack and give way without warning when least expected.

Cast-iron, too, is most unreliable, in fact, dangerous in the extreme; inasmuch as it cannot resist sudden shocks of any kind, which are especially present in cases of fire, when the iron, after having been heated by the flames, is suddenly cooled with cold water from the hose, which makes it crack immediately, entailing the total collapse of the whole structure generally.

Wrought-iron is certainly not so treacherous; but still it is dangerous, on account of its liability to twist and expand under intense heat, thrusting the walls out.

Hence it is always advisable to encase iron parts of structures with some material which is itself really fireproof, before the work can be said to be "proof against the effects of fire." The only materials which can be said to possess these requisite properties are—fire-clay in any burnt form, concrete of cement, and breeze, or other similar agglomerates, as well as plaster of various kinds.

Brick Arches are the simplest and most effective fire proof material, though only suitable for small spans, except where the height of the space which they and their rise occupy is of no consequence. In large spans, and where this is a consideration, their success and usefulness are diminished by the insertion of encased structural parts of iron, whether cast, for columns, or wrought, for girders, whereby the floor-space is cut up into sections, and filled in by arches springing from the encased wrought-iron girders. The spandrils of these arches are levelled up to the crown with cement-concrete, whereon the ordinary floors are constructed. The only objections which can be raised against brick arches, apart from the supplementary ironwork, are that they are heavy and complicated, and take up too much room, besides being expensive; but these are held to be serious if not fatal objections; and they are considerably intensified by the insertion of iron girders, which, whether cased or uncased, render the floor very complicated in construction, and dangerous, unless the girders are tied together by rods, etc., to withstand the thrusts caused by the arches themselves.

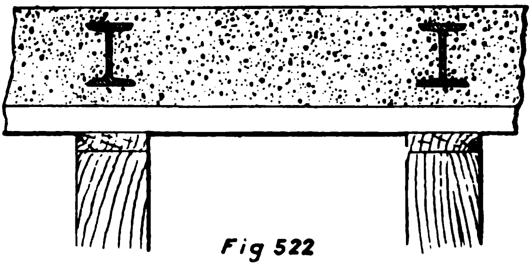


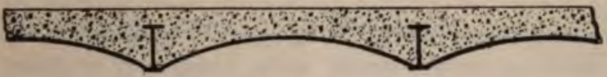
Fig 522

Concrete Floors.—Consequently, recourse has been necessary to other, lighter, and more simple methods, which will give as much security as possible from the ravages of fire. Thus, the mode of construction that has been settled upon as being most free from complications, and the cheapest, is that of concrete areas, supported by iron joists embedded within the thickness of the concrete itself, which need not be very deep in floors of ordinary spans; and this is an important consideration, as the thicker the floor the higher the building must be to give the same amount of space.

Where the span necessitates the employment of binders, or girders, to support the iron joists which uphold the concrete areas, care should be taken that these additional members are enclosed or surrounded by a casing of fire-clay, concrete, or other non-inflammable material, to protect the iron.

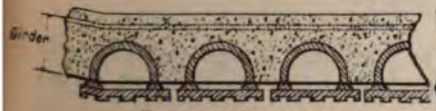
A great advantage of these and other kinds of concrete or fireproof floors is that a new building, so far as internal arrangements are concerned, can be constructed from floor to floor without so much trouble to secure the placing of wall over wall, and in similar constructive details; though of course the floor must be made strong enough in itself to allow of such liberties.

As before explained, a concrete floor composed of breeze, slag, brick-dust, or other non-inflammable materials, mixed with cement in such proportions as the situation and character of the work call for (usually in the proportion of 4 or 5 to 1 of cement), is the best form of fireproof floor. It is illustrated by fig. 522, the iron joists being fixed about 2 feet apart; after which a temporary wood platform is built underneath it, to support the concrete until it has set hard; and this is fixed below the bottom of the joists, so as to allow of the concrete encircling the iron, as shown.

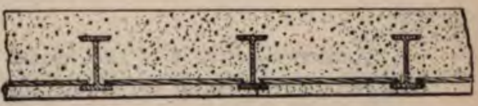


Dennett's system
Fig 523

Special Systems.—The principles of concrete floors having been explained, and the various points to be considered and guarded against thus brought to the notice of the student, it only remains to set forth the different systems which have been invented and introduced of late years; those which conform to the principles already laid down being, of course, the best. The following is a list of the chief British systems in use:—



Fawcett's System
Fig 524



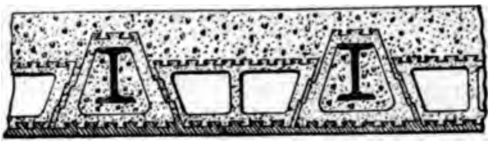
Fox and Barrett's System
Fig 525

Dennett's, as illustrated by fig. 523, will be seen to consist of iron girders and concrete arches of various spans, not exceeding 12 feet, and rising no less than 1 inch per foot. The matrix of the concrete is gypsum, which has been proved to retain coherence even when burnt or drenched with water, or both in succession.

Fawcett's, consisting of iron girders, 2 or 3 feet apart, the interspaces being filled in with earthenware pipes of hollow arched section laid diagonally, on which a 6-inch layer of breeze and cement concrete is laid, is illustrated by fig. 524.

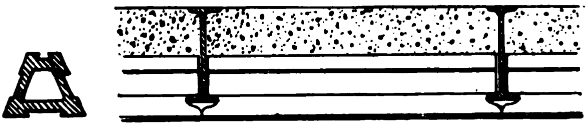
Fox and Barrett's, as fig. 525 explains, consists of iron girders, spaced at intervals every 20 inches, between which wood strips are placed, and the whole covered with concrete, rising above the girders, as shown.

Hornblower's consists of hollow fire-clay tubes, of wedge-shaped form, springing from blocks of similar material encircling wrought-iron girders bedded in concrete about 26 inches apart, as fig. 526, the top being levelled over the same as shown.



Hornblower's System
Fig 526

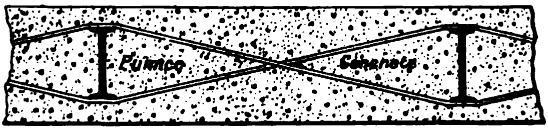
Homan and Rogers' patent, as fig. 527, is made up of iron girders, between which are placed special bricks, which may be glazed or ornamental on soffit; and the top is filled up with concrete, the same as the other methods.



Section of bricks

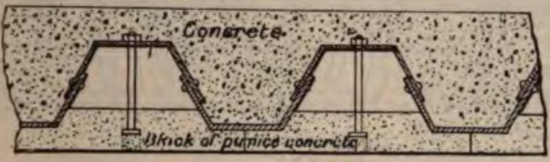
Longitudinal Section
Homan & Rodger's System
Fig 527

Lindsay's patent is of two kinds, as illustrated by figs. 528 and 529; the former consisting of wrought-iron or steel joists, spaced 18 inches apart, and laced together, as it were, by wrought-iron rods or strips passing over and under each one alternately, as shown; the whole of the iron being then encased in what is called pumice concrete, which is really made of breeze and cement, being much lighter than the ordinary mixture.



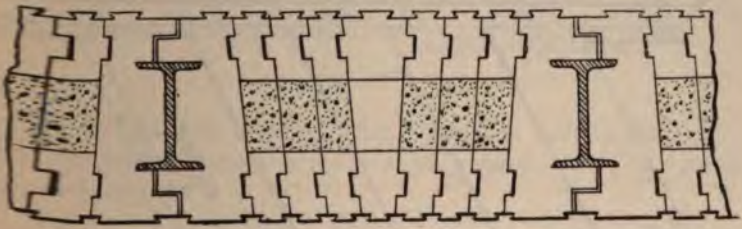
Lindsay's system with I Girders
Fig 528

The other method, very much used for goods-sheds, etc., as fig. 529, will be seen to consist of wrought-iron troughs, riveted together over the whole area, and the top spaces are filled with the usual concrete and levelled for the floor in the ordinary way; and for the purpose of covering the underside, which is very necessary to render it complete, cast blocks of breeze or pumice are bolted up to the underside, as shown on the illustration.

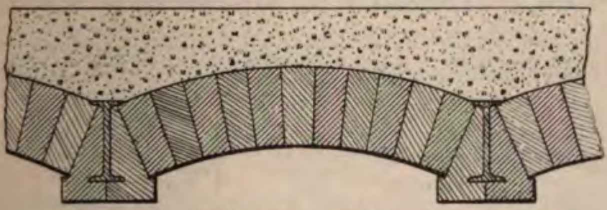


Lindsay's System with trough girders
Fig 529

Measure's patent is similar to Fox and Barrett's, with the distinction that the girders are spaced 3 or 4 feet apart, and T-irons, about 9 inches centre to centre, span them from flange to flange, and support the usual concrete.



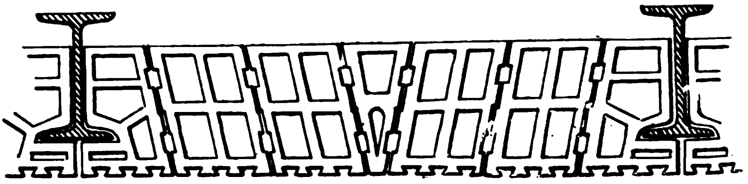
Northcroft's System
Fig 530



Whichcords System
Fig 531

Moreland's system consists of wrought-iron girders, supporting curved intermediate girders, at right angles to the main girders, and covered over with corrugated iron, on which the concrete is laid and levelled up as before.

Northcroft's consists of two layers of flat arches, of special wedge-shaped bricks, resting on similar skewbacks, supported by wrought-iron joists, as fig. 530, the spaces above and between the arches being filled up with concrete.



Doulton and Peto's
Fig 532

Whichcord's method consists of solid fire-clay arches springing from fire-clay springers, enclosing the wrought-iron girders as fig. 531, and filled up with concrete.

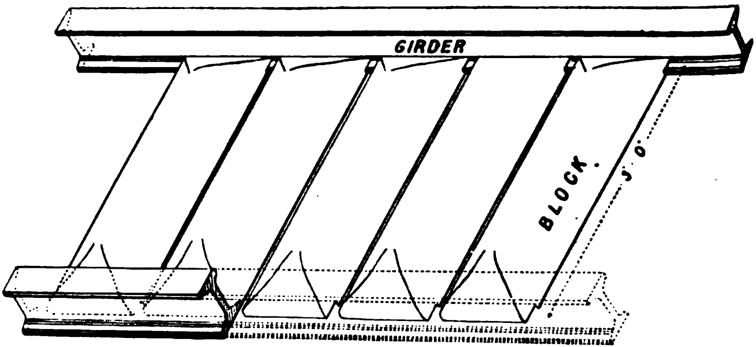


Fig. 532A

Doulton and Peto's variety, as fig. 532, consists of fireproof hollow-keyed blocks, which encircle the lower parts of the girders, as well as form a strong light floor of simple construction.

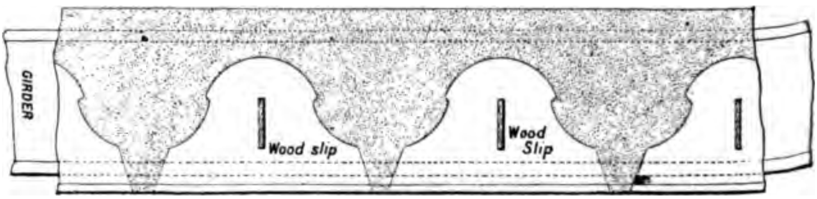


Fig. 532B

The *Adamant Company's* system consists of blocks of concrete and adamant cement placed from joist to joist, as figs. 532A and 532B, and covered over and levelled with ordinary concrete suited to the locality. The girders can be placed 3 feet apart, and the blocks are cast with a wood strip on edge embedded in them, in order to be the better able to resist tension.

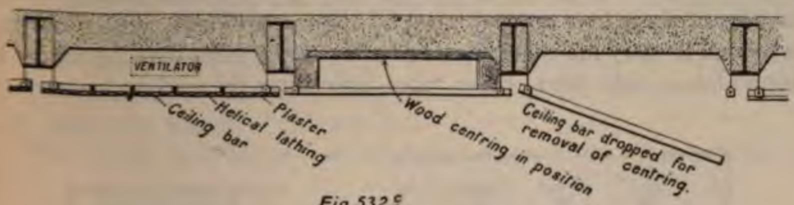

VENTILATOR
Ceiling bar
Helical lathing
Plaster
Wood centring in position
Ceiling bar dropped for removal of centring.

Fig. 532C

Banks's patent, fig. 532C, completely protects the steel work—which is a distinct gain; and there are other advantages, such as its ready application to existing floors and its ventilating space, which the illustration sufficiently explains.

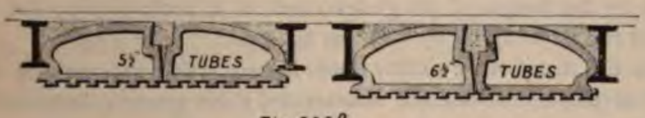


Fig. 532D

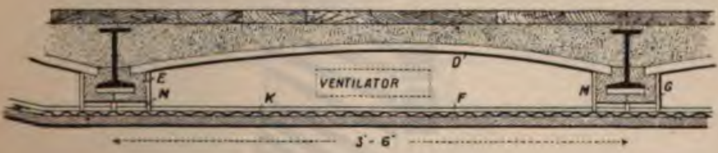


Fig. 532E

The "*Carlisle*" fireproof floor, fig. 532D, consists of two tubes forming an arch between the joists, which have to be bolted together to resist the thrust successfully; they are covered with concrete in the usual way, and provide in themselves a space for ventilating and other purposes.

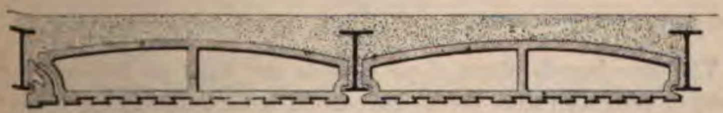


Fig. 532F

Potter's system is somewhat similar, fig. 532E; but the lintels are in one piece, requiring no bolts.

Picking's, fig. 532F, is almost a combination of the last two, as the illustration explains.

Pease's patent, figs. 532G and 532H, a very ingenious arrangement, consists of sheet iron or steel tubes, so constructed that a cup, as it were, is formed to carry the concrete as a centre; at the same time the whole is bound into a solid mass; these tubes, which can be used as long as 12 feet, rest on the flanges of the girders, and as a protection to the underside slabs can be hung up by bolts, as fig. 532G.

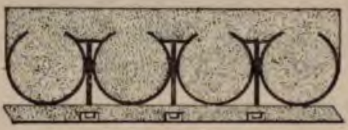


Fig. 532^{G}

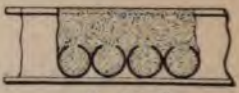


Fig. 532^{H}

There are many other similar floors in use, which are perhaps equally as good as those hereinbefore enumerated; the general disadvantage of most of them is their disposition to conduct sound from floor to ceiling, necessitating the use, very often, of counter-ceilings, with an intermediate space, which is the best non-conductor. It will be noticed how most of them endeavour to attain this end in the floor itself.

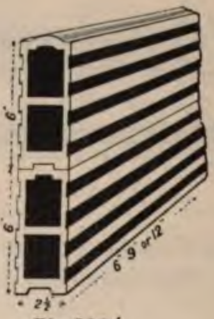


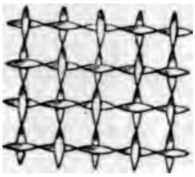
Fig. 532^{J}

The floor-boards above these systems are fixed to dove-tailed wood fillets, or Wright's patent breeze dove-tailed blocks, embedded in the concrete, and made level as the ordinary joists, similar to fig. 533; while the wrought-iron members, unprotected underneath, are, or should be, covered with patent wire-wove material, which keeps up the concrete casing, and forms a key for the plastering for ceilings and ornamental beams.

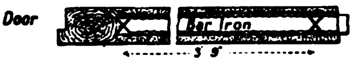
Fireproof partitions are constructed with tubes on Pease's principle, or by hollow blocks, as fig. 532J, which are light, and made that they lock together, forming a solid mass—this is Picking's arrangement; and Banks has a patent consisting of steel X-shaped standards, with a double row of helical lathing, fig. 532K and fig. 532L, plastered similarly to the ceilings in his patent floor.

Wood-blocks are generally used as the covering on fireproof floors, the surface of the concrete being floated over with Portland cement and sand, and rendered perfectly level.

The blocks may be of any regular thickness from 1¼ inches up to 2½ inches, the ordinary kind being from 9 to 18 inches long and about 3 inches wide; and it is absolutely necessary that they be truly square, so that when laid they fit together well. Moreover, it is most important that they are thoroughly dry, and they should not be brought on to the building until the cement screed or bed is quite dry, and they are actually required for use. Very often good dry blocks are brought into a building which cannot be really dry; and whilst they are waiting to be laid, they absorb the moisture of the building and surroundings, with the result that they swell, and in this condition they are laid, and as soon as they and the building get dry they shrink, and show large cracks, and in many cases they even rise up.



Helical Lathing
Fig. 532^K



Plan Hollow Partition.
Fig. 532^L

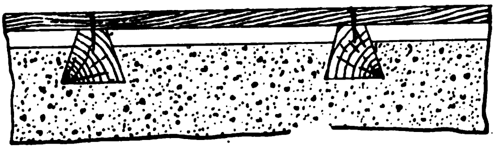


Fig 533

A wood-block floor can be laid to designs and patterns in any kind of wood, and they are kept down in their positions by a solution containing pitch, resin, and other patented mixtures, which are of a sticky nature when hot, and on cooling are so cohesive that they keep the blocks and screeding together.

There are several patent systems of laying these blocks, the general principle being to form keys or dovetails—this end being attained by a triangular sinking or groove made in the edges of the blocks, close down to the bottom, so that the solution on the bed can be pressed up into the grooves formed between the blocks. This dovetail keying is also formed by small iron channels embedded in the cement screeding. Another idea is to keep down the blocks by dowelling them together, and Stockholm tar is used to make them adhere to the cement bed.

In hospitals and other similar buildings teak or other hard-wood ordinary floor boards are secretly nailed directly on to the cement screed itself without the fillets shown in fig. 533.

CHAPTER XVI.

JOINTS AND MOULDINGS IN JOINERY.

Joinery Defined—Framed Joints—Angle Joints—Dovetails—Scribing—Mouldings—Match Boarding—Affixing Joinery Work.

Joinery Defined.—The term "joinery," applied in a general sense, includes all the finishings to the carcase of a building, whether they be external or internal, such as doors, windows, stairs, skirtings, skylights, lanterns, dadoes, and other panelling,—in fact, it may be said to include everything which is planed and wrought up to a nice smooth and often ornamental face, and framed together in such a workmanlike and precise manner that it is difficult to discern the joints unless helped by the different grain and colour of the "stuff," as the wood is called.

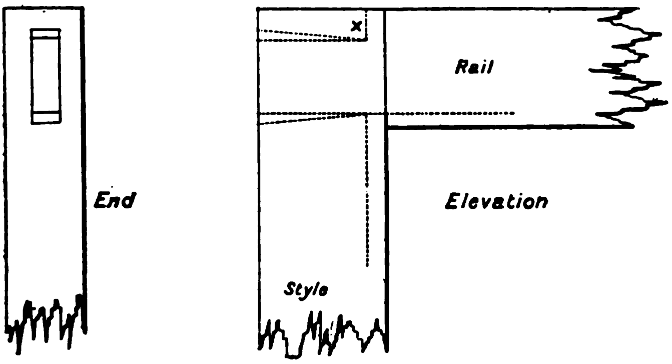


Fig 534

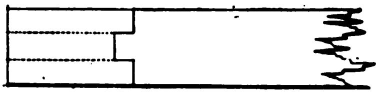


Fig 534 Plan

It is intended to devote most of this chapter to a description of the various joints, mouldings, and terms which are used in this particular branch of building; but the principal and most common joints, etc., will be again pointed out to the student when they are met with in the different kinds of joiner's work which will be dealt with in the course of these lessons.

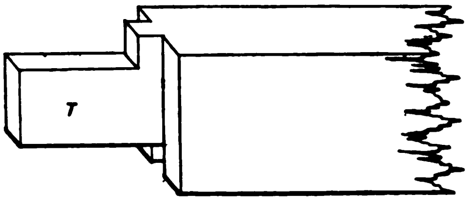


Fig 535

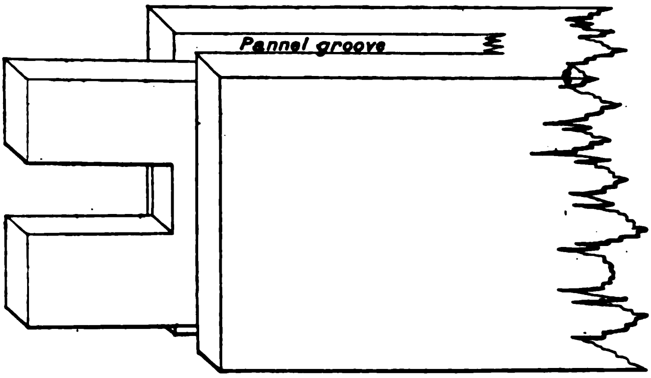


Fig 536

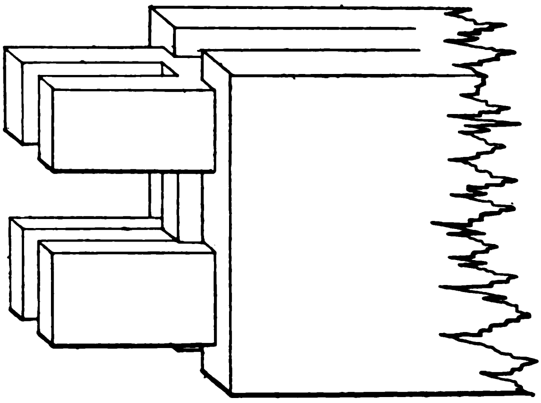
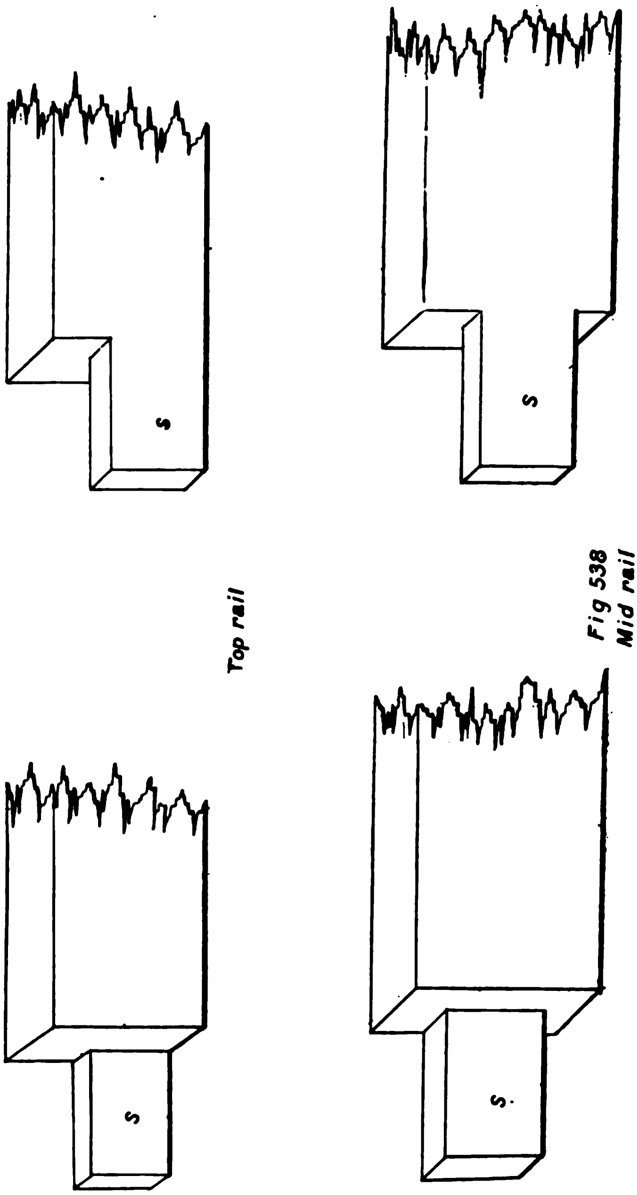


Fig 537

Framed Joints.—The *mortise and tenon* is the chief and most common of all joints used in joinery framing. All rails of doors, for instance, are tenoned through the styles and wedged up tight, as fig. 534, the tenon usually being one-third of the thickness, and with a haunch left s at X, to fill up the panel groove on the styles and strengthen the . This is the origin of the term *haunched* tenon, a sketch of which,



Top rail

Fig 538
Mid rail

is on the rail before being wedged up into the styles (as shown on 34), is given (fig. 535).

On wide rails, such as lock or middle and bottom rails, this tenon is in two parts in its depth, as fig. 536; and where doors are more than 2 inches thick, or where provision has to be made for a mortise lock, which, when let into the centre of the style, at lock rail height, completely cuts away a central single tenon, the tenons are double in thickness, and called *double tenons*, as fig. 537.

A *bare-faced* tenon is a tenon with only one shoulder, S, used chiefly in framed ledged and braced doors, where the rails are not so thick as the styles by the thickness of the boarding nailed on the rails between the styles. Fig. 538 illustrates a bare-faced tenon, one view being given of each side.

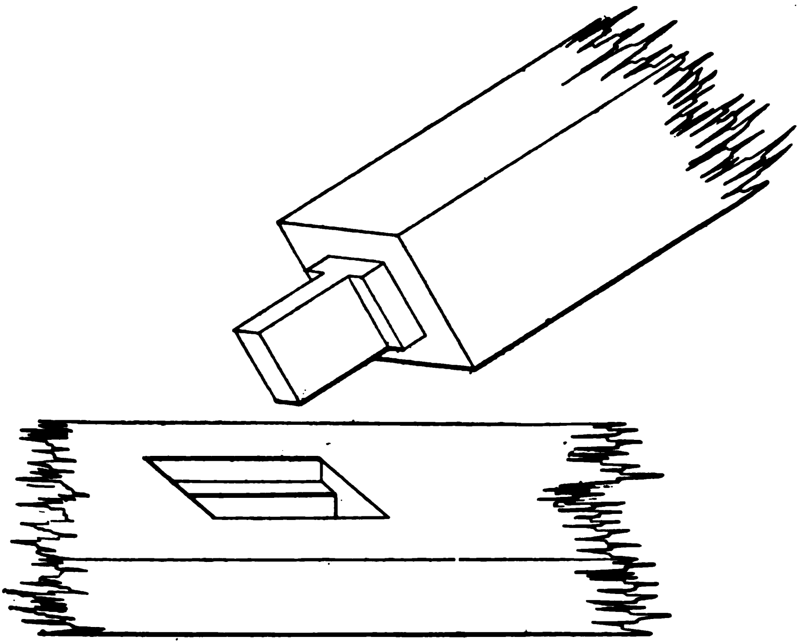


Fig. 539

Stump tenons are those which have a projection on each side of them to go into mortises part of the way of the principal mortise. They were designed to give the tenons on the thinner stuff greater strength, and to hold into wider mortises on the wider. Fig. 539 represents a stump tenon and its mortise.

A *housed* tenon is a tenon let into a mortise with the section of the stuff let into the mortise to the depth of half an inch, as fig. 540.

Angle Joints.—*Tongued angles* are used for internal angles of dadoes, skirtings, grounds, casings, etc., as fig. 541.

Mitred angles are made by simply cutting half a right angle alternately ff the two pieces, to be joined by nails at an external angle, as fig. 542.

Mitred and tongued angles, a combination of the two last, are as

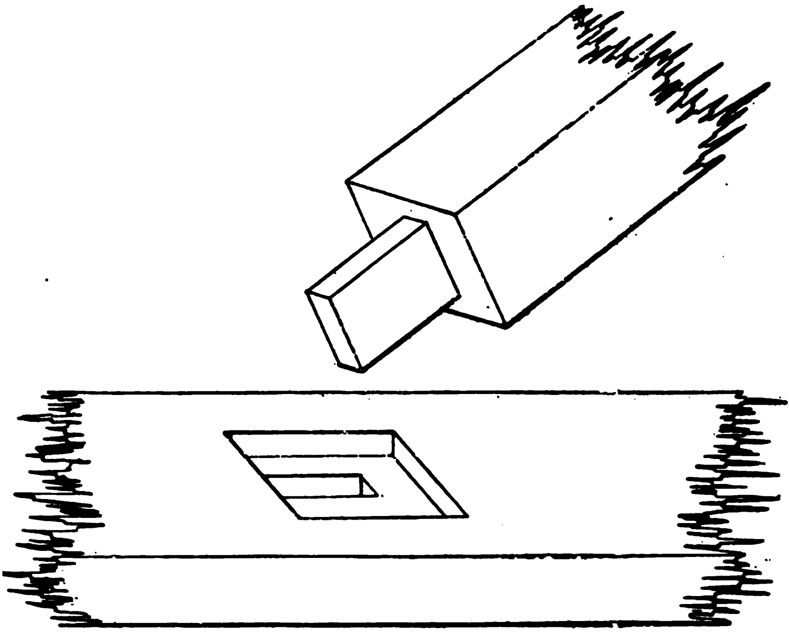
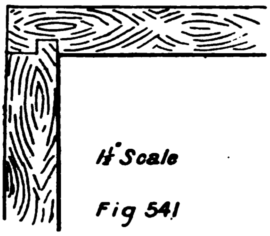
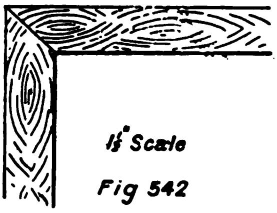


Fig 540



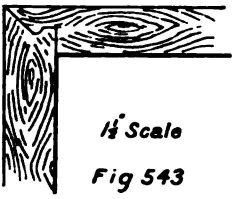
1½" Scale

Fig 541



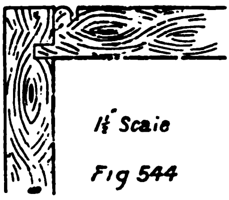
1½" Scale

Fig 542



1½" Scale

Fig 543



1½" Scale

Fig 544

. 543, and are only used in best work, at the external angles of dadoes, lasters, etc.

Beaded and tongued angles, illustrated by fig. 544, are angles or ints of an ornamental as well as necessary character.

Return-beaded angles are suitable for all external mitres where wear and tear would soon fetch the arrises off in soft woods. Fig. 545 shows one on wood framing, casings, etc., and fig. 546 one as fixed to angles to plastering on wood, brick, or stone walls, to which they are fixed by plug, as will be explained hereinafter, this being called a *staff* bead.

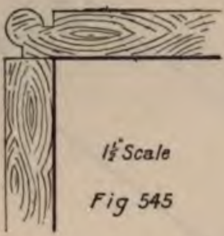


Fig 545

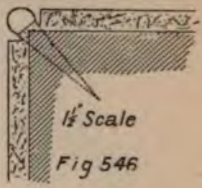


Fig 546

Where the two pieces of framing to be joined are of different widths or thicknesses the "mitred angle" is made as fig. 547.

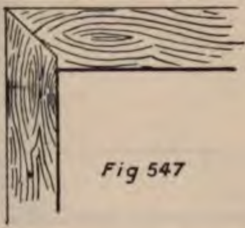


Fig 547

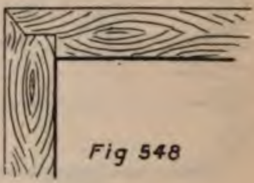


Fig 548

Another form, of very good construction, is as fig. 548.

Keyed mitred joints are not often used; but it is as well that the student should know what they are. Fig. 549 is a view of the angle of one, X X, being hardwood-slips let into the mitres.

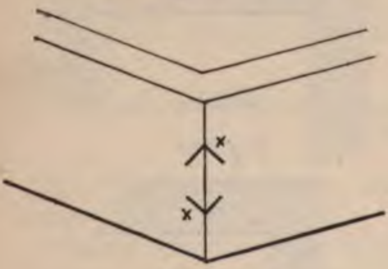


Fig 549

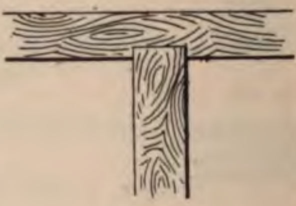


Fig 550

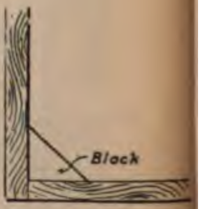


Fig 551

Housed joints are as fig. 550, by which the whole thickness of the cross-framing is let into the other about half an inch.

Glued and blocked joints are really butt or lapped joints secured by blocks glued to each piece of wood in the internal angle (fig. 551).

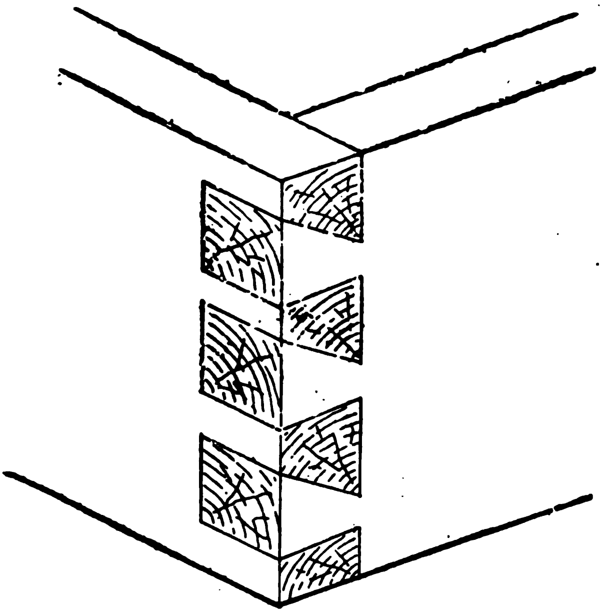


Fig 552

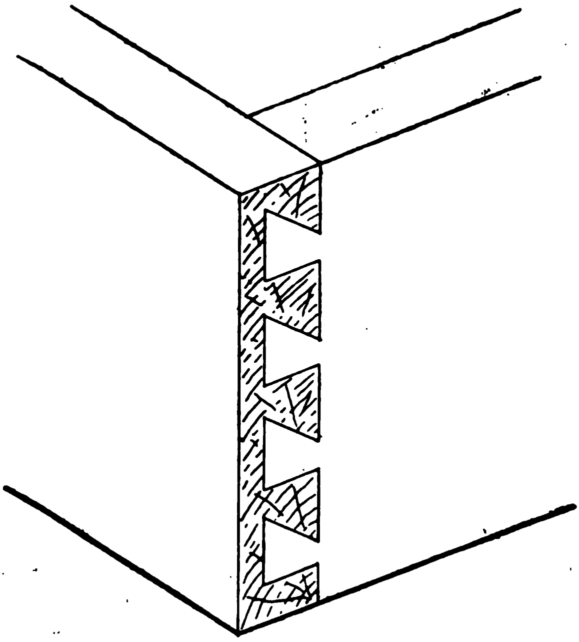


Fig 552ª

Dovetails, the most common of the intricate and strong joints, are used for cisterns, square casings, or curbs to skylights, and the corners of drawers and other fittings. There are three kinds: the *common*, as fig. 552; the *lap*, as fig. 552*a*; and the *secret* or *mitred*, the most troublesome of the three, as fig. 552*b*. It will be seen that they consist of wedge-shaped alternate cuttings out of each piece, the projections of the one fitting the holes on the other.

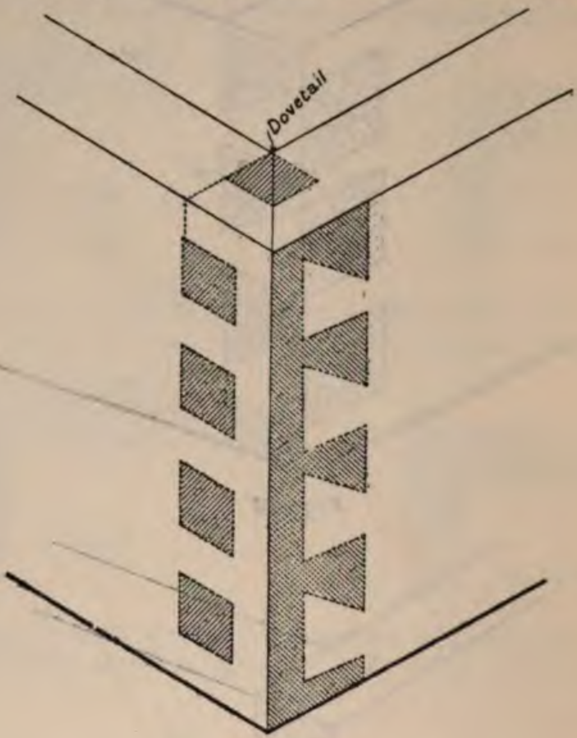


Fig. 552b

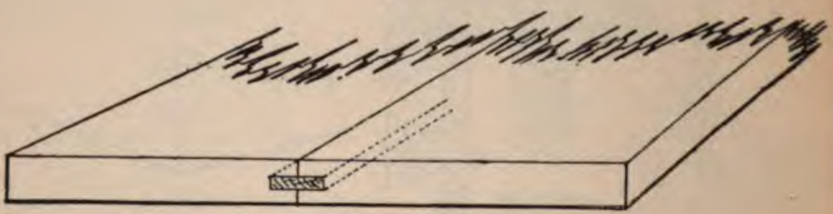


Fig 553

Cross-tonguing is the method of joining two or more boards longitudinally, a loose tongue being glued and let into a groove on each board, as fig. 553. This loose tongue is sometimes called a *slip feather*, and is made of wood across the grain. *Long* (the opposite to cross) tongues have the grain of the wood in the direction of their length.

Clamping is the method by which the ends of several boards are fastened together, as shown on the left-hand of fig. 554; while the right-hand side of the same figure illustrates *mitre*-clamping, by which the cross-grain end of the ordinary clamping is obscured.

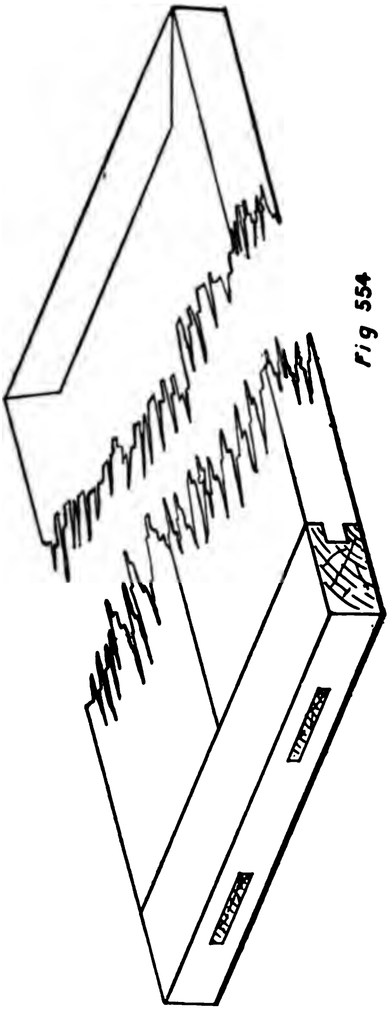


Fig 554

Keying (fig. 555) is a means of securing several boards together by a flush key, let in at the back in lieu of a projecting ledge, where the latter would be inconvenient on account of a level face being required on each side. This is often used in the North for wide door casings.

Keyed joints are also used to connect circular with straight or two pieces of circular wood, such as door frames, etc. A shallow mortise is cut out of each part, and a hardwood key (in the form of the letter I) connects the two together, as fig. 556, X X being wedges to tighten up the joint.

Fig. 557 illustrates *Fox wedging*, a means by which tenons are secured into shallow mortises, where wedges cannot be driven in from the other side.

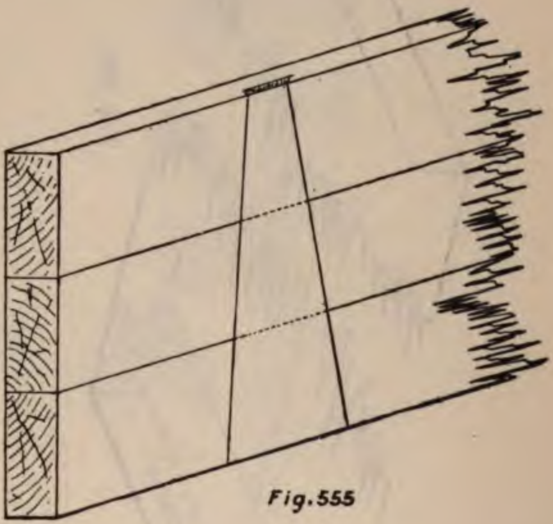


Fig. 555

Scribing is the cutting, out of the face of one moulding, a hole of the contour of another to form a joint. It is chiefly used in joints of sash-bars, internal angles of moulded skirtings, etc., and really is a moulded mortise cut into another moulding to receive a moulded tenon of the same section as the mortise, but in a converse form. For instance, in fig. 558, it will be noticed that on A a moulded mortise or notching is cut out, with the ovolo hollow, as it were; and on B, which we will call the tenon, the cutting has the ovolo convex or projecting to fit and fill up the hollow on A.

A *scribed housing* is a housing made to the contour of the moulding it is going to receive (fig. 559).

Other kinds of joints, principally used for flooring, will be found fully illustrated and explained in Chapter VIII.

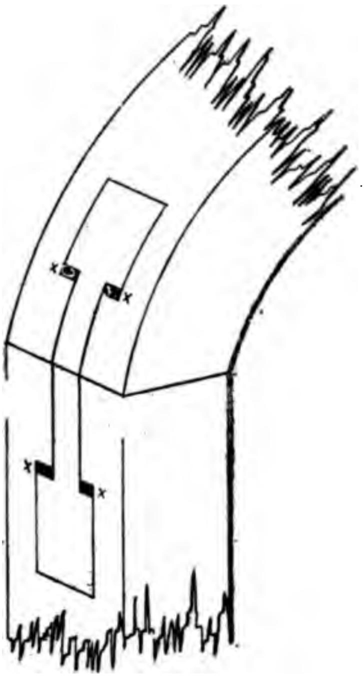


Fig 556

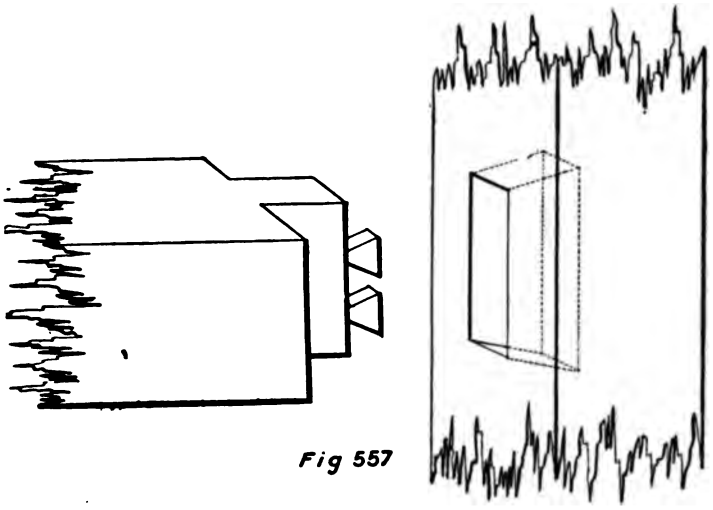


Fig 557

uldings.—Mouldings are a series of sinkings and projections of forms—mostly parts of circles, ellipses, etc.—worked on the edges of the wood to produce light and shade by shadows, and give it an ornamental and showy appearance. They are of two kinds—*stuck* and

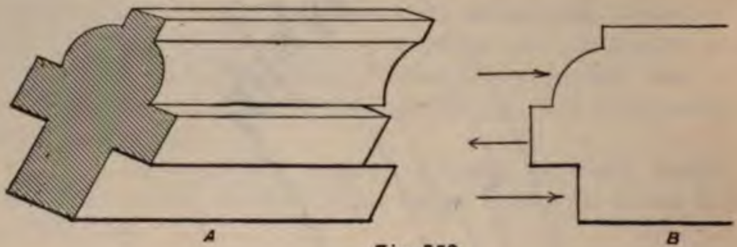


Fig 558

planted, or *laid in*; the former denoting that the moulding has been worked on the solid edges of the stuff, as in fig. 560; and the latter that

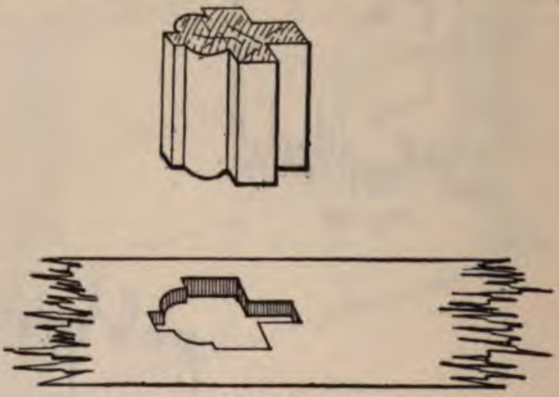


Fig 559

it is a separate slip, moulded and attached to the side of the framing by brads and glue, as fig. 561.

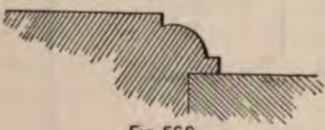


Fig 560

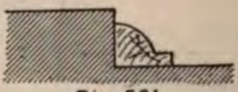


Fig 561

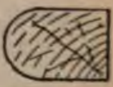


Fig 562

The chief parts of moulding are as follows:—

The *bead* (fig. 562) is the most useful, being often utilised for covering joints, etc., and as a nosing to round off edges, when it is called a "rounded nosing."

The *quirked bead* has a sinking on one side, as fig. 563, and the *double quirked* has one on each side (see fig. 564). They are required to give a limit produced by the shadow.

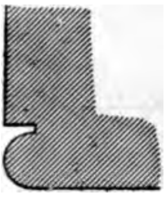


Fig 563

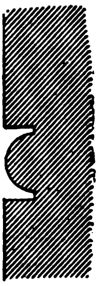


Fig 564

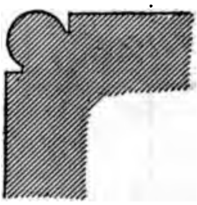


Fig 565

The *return* or *staff* head—"return" being the joiner's term, and "staff" the carpenter's term—fig. 565, is used for exposed angles, where arrises would soon be knocked off.

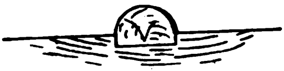


Fig 566

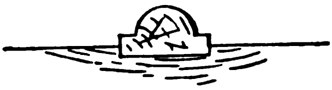


Fig 567

The *cocked* bead—named after its projection from the face line—is as fig. 566.

Cocked bead and fillet is as fig. 567.

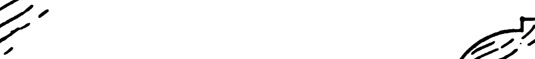


Fig 568

Where several beads are placed together they are called *reeding* (fig. 568).

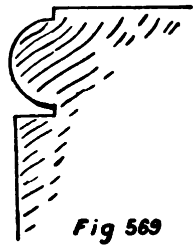


Fig 569

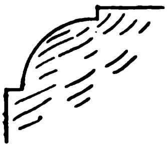


Fig 570

The *Torus* is a bead with an extra fillet (fig. 569).

The *Ovolo* is a quarter of a circle with a fillet on either side, as fig. 570.

It can also be a part of an ellipse or any other circular figure. A sash bar is formed by a "double ovolo," as fig. 571.

The *Cavetto* is the reverse to the ovolo (fig. 572), hollow in form.

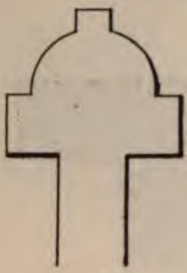


Fig 571.

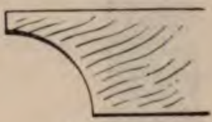


Fig 572

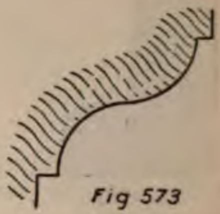


Fig 573

Ogee, or the "Cyma recta" mouldings, are made up of parts of two circles which touch one another, as fig. 574.

Cyma reversa, or the reverse ogee, as fig. 573, explains itself.

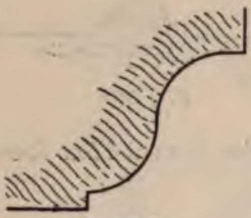


Fig 574

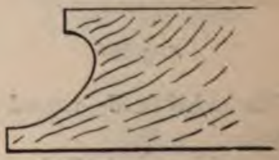


Fig 575

The *Scotia*, a moulding chiefly used for bases, is similar to fig. 575.

Mouldings are often made up of two or more of the above forms grouped together, when they are known or distinguished by the combined name. Thus fig. 576, consisting of a *quirk ovolo* (any moulding can be quirked by the addition of the sinking on one side) and a *bead*, is called a *quirk ovolo and bead* moulding.

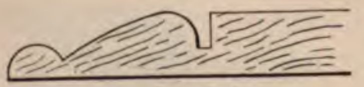


Fig 576

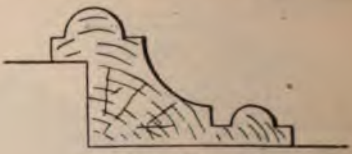


Fig 577

Bolection mouldings are those which are rebated out at the side, and project above the face of the panelling it is intended to ornament (fig. 577).

Chamfering is the taking off of the arris or sharp edge of any angle, as fig. 578, the angular groove formed by the meeting of two chamfered angles (fig. 579) being called a V joint.

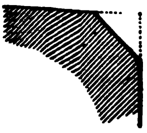


Fig 578

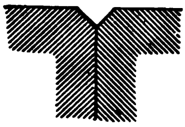


Fig 579

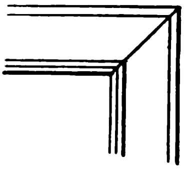


Fig 580

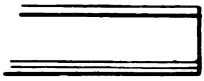


Fig 581

Mouldings, etc., are united at internal angles, as in fig. 580, stopped at ends (fig. 581), and returned at extreme angles (fig. 582), when the contour of the mould is exposed to view.

Match Boarding.—This is an arrangement of boards matched and put together with grooved and tongued joints, and their edges "shot" or planed truly, so that a fine joint can be made. Match boarding, otherwise called *cleading*, is of several kinds, the chief of which are:—

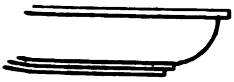


Fig 582

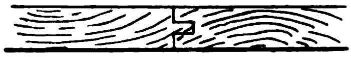


Fig 583

Plain matched boards (fig. 583).
Beaded-one-side match boarding (fig. 584).
Beaded-both-sides match boarding (fig. 585).
V-jointed match boarding (fig. 586).

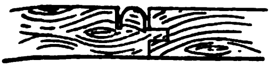


Fig 584

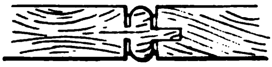


Fig 585

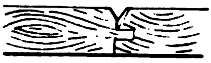


Fig 586

Affixing of Joinery Work.—Joinery work is fixed to either *plugs*, *grounds*, or *backings*.

Plugging is done by means of wood wedge-shaped plugs, which are driven into the vertical joints of the bricks, and cut off to a level face, to which the other woodwork is secured by nailing (fig. 587).

Grounds are used in better work, being wrought and splayed to form a key for the plaster. They are nailed to plugs in the cross-joints, as fig. 588; or to wood or breeze bricks, fig. 589; or to elm pads, fig. 590; which the bricklayer builds in the cross-joints for the carpenter to fix to.

The grounds are "framed" (that is, dovetailed) at external, and tongued at internal angles, in the very best work. To doors and windows

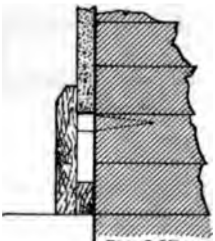


Fig. 587
1" Scale

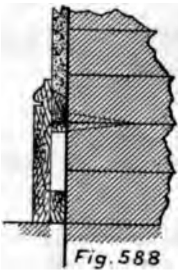


Fig. 588

1" Scale

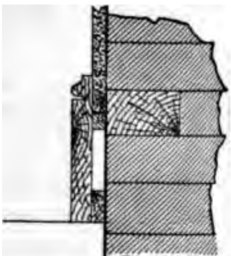


Fig. 589.

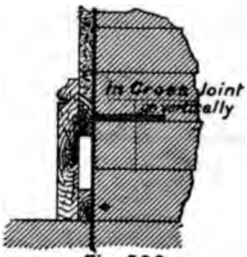


Fig. 590

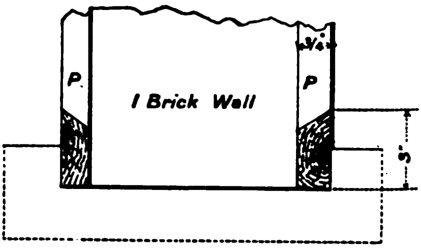


Fig. 591

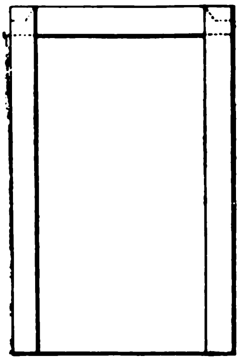


Fig. 592

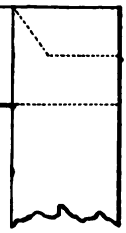


Fig. 593

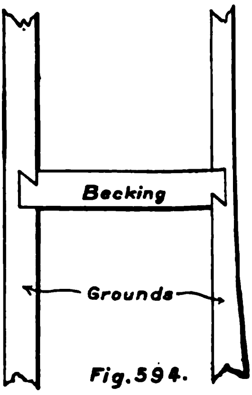


Fig. 594.

they are splayed to receive and "key" in the plastering, being fixed perfectly "plumb" or perpendicular to the plugs, bricks, or palettes encircling the door or window, except at the floor line. Fig. 591 represents an enlarged plan of a door-jamb, and fig. 592 an elevation to a smaller scale.

The dotted line on fig. 591 represents the gauge to fix by. The angles at X on fig. 592 are joined by a *bevelled haunching*, as fig. 593, in the elevation, drawn to a larger scale.

Backings are pieces of wood framed in between the grounds to form a backing and fixing for linings, window boards, and other wide joinery, requiring to be fixed against anything, as fig. 594.

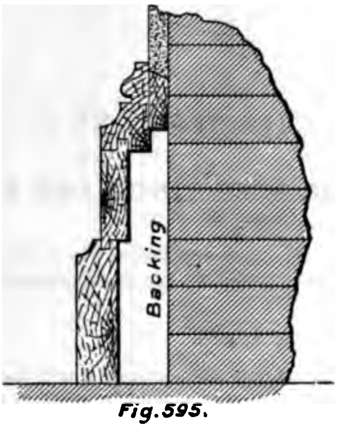


Fig. 595.
1" Scale

Shaped backings are those which are cut and notched to receive irregular framing or different members, as skirtings, etc., in best work. (See fig. 595.)

For ordinary skirtings a fillet is run along the walls, on the floor, to receive the bottom of the skirting, as X, fig. 590.

All first-class work should be fixed to grounds in lieu of plugs, which are only fit for inferior common work; and when the grounds are fixed perfectly true vertically and horizontally, there is no difficulty in affixing the joinery without fitting, cutting, and scribing; and moreover the plasterer finishes his work with greater truth in his surfaces, as he has perfectly true substantial grounds to straighten from.

CHAPTER XVII.

DOORS: THEIR FINISHINGS AND FASTENINGS.

Door Frames—Ledged Door—Ledged and Braced Door—Framed and Braced D
Framed and Ledged Door—Fanlights—Panelled Doors and Panelling—Door C
—Dadoes—Skirtings.

BEFORE dealing with the doors themselves it will be advisable to ac a thorough understanding of the frames or cases which are designe contain them. These frames, being generally built up in reveals fo

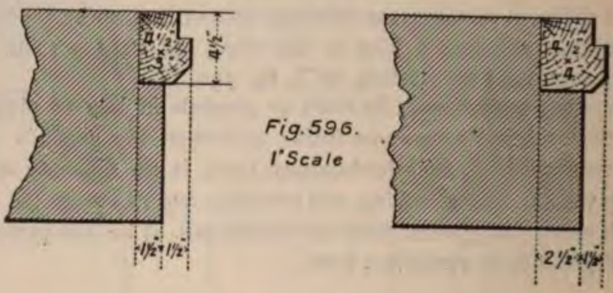


Fig. 596.
1" Scale

in the brickwork as the work proceeds, have to be no less than 4½ in wide—the width or half the length of an ordinary brick—and 3 or 4 in deep, according to requirements and the depths of the jambs. The fr usually projects about 1½ inches beyond the face or "sight size" of opening (fig. 596).

The frames are made up of two jambs (or legs), as the posts are ca and a flat or arched head, according to the nature of the opening (fig. both jambs and head being, of course, of the same size. The jambs tenoned into the head and wedged, the head generally being 3 in onger beyond each side of the jambs. These projections are called horns, and are intended to be built into the walls.

Fig. 598 represents a frame for a square-headed door, the jambs of which are tenoned into the head.

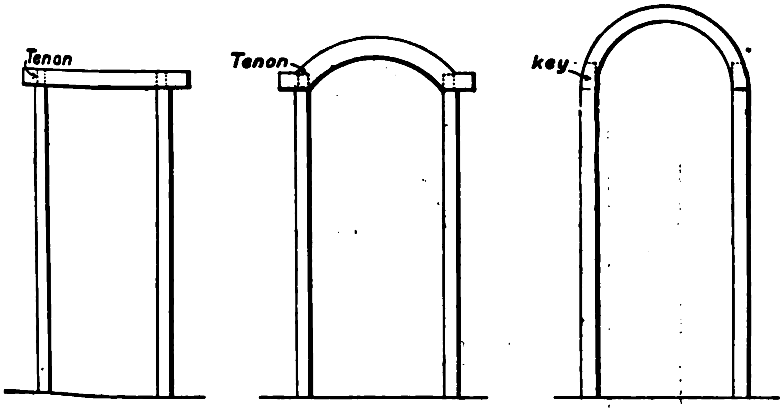


Fig. 597.
¼" Scale

Fig. 599 shows the head cut out for a segmental-headed door, the joints at the top being similar to the last, and the head being cut out of a deeper piece of stuff.

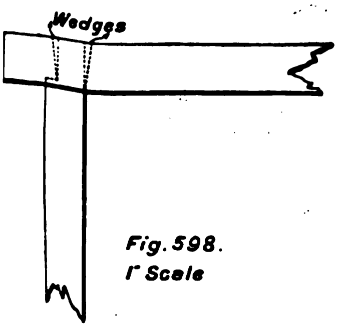


Fig. 598.
1" Scale

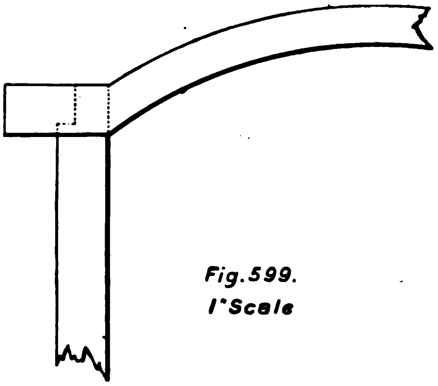


Fig. 599.
1" Scale

Fig. 600 represents a frame for a semi-circular-headed door, the joints at the springing being as shown, and the key being formed on the top of the jamb, and let into a mortise in the circular head and wedged up tightly. The joint at the crown is made similar to fig. 556, and sometimes also that t the springing, exactly as shown in that figure (*vide* Chapter XVI.).

Door frames are secured at the foot of the jambs by dowels let into the jambs and steps, as in fig. 601; or in best work, where the bottoms are apt to rot away from the damp that rises, they are dowelled into projecting stones worked to the same section as the frame (fig. 602), and painted, so that the difference cannot be noticed at first sight. These are sometimes called *cotch* stones.

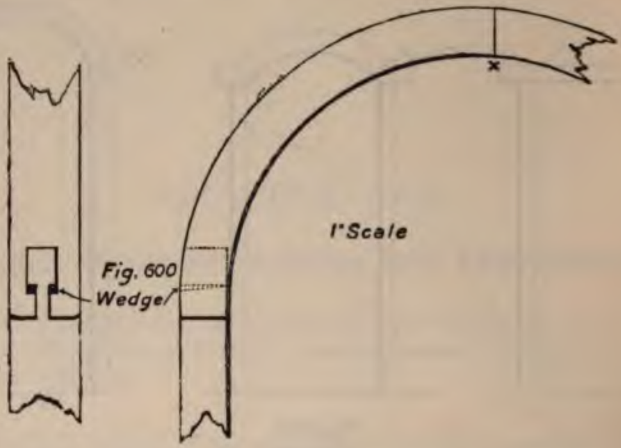


Fig. 600

Another method is to let the bottom of the jambs into cast-iron shoes —also of the same section as the frames—which are secured to the stone sills.

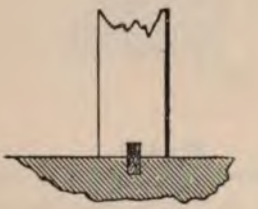


Fig. 601.

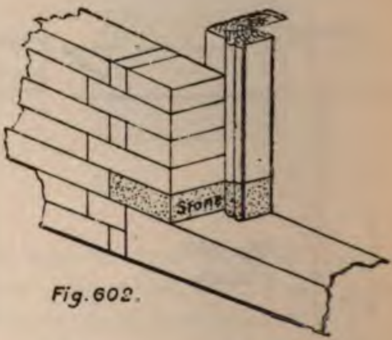


Fig. 602.

The frames, when built as the work proceeds, are often tied in with wrought-iron ties, two or three in each height, one end turned into the wall, and the other secured to the back of the frame (as fig. 603).

In sections the frames, of course, vary according to the requirements and nature of the work; but all are *rebated* for the door.

Fig. 604 is a section of a rebated and chamfered frame.

Fig. 605, that of a rebated and moulded frame.

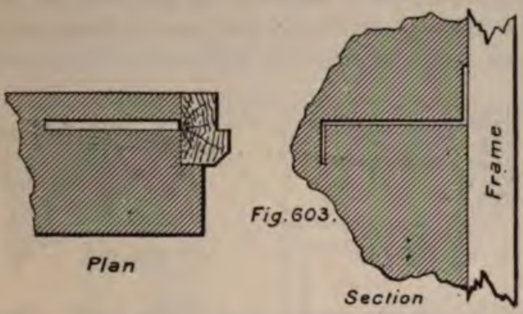


Fig. 603.

Fig. 606, a rebated and beaded frame.

The rear faces, abutting against the brick or stone rebates, are often grooved for the plastering or linings, in addition to the other labour named above (fig. 607).

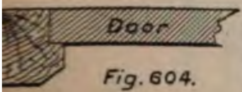


Fig. 604.

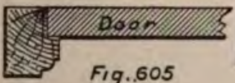


Fig. 605

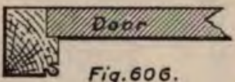


Fig. 606.

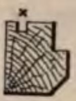


Fig. 607

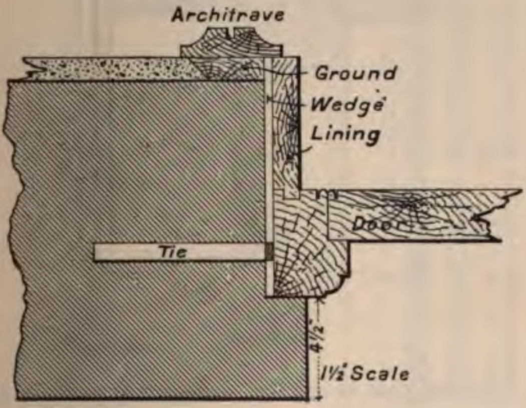


Fig. 608.

Fig. 608 represents the plan of the jamb of a frame with door linings and finishings in an ordinary 9-inch reveal.

Often, to break the joint in best work, the side of the rebate and the door are beaded, as in fig. 609, or the arris of each is taken off and forms a V joint, as in fig. 610.

The section of the head is similar to fig. 611, with the addition of the elevation of the return of the linings, etc., as seen down the jamb.

In very wide walls, in first-class houses, the linings are panelled, as fig. 612, which represents a section through the head. The jamb would be the same, without the elevation lines shown on.

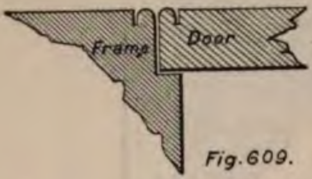


Fig. 609.

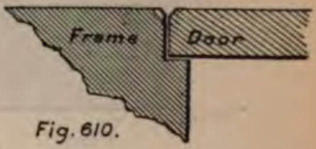


Fig. 610.

N.B.—Students—when drawing plans and sections of moulded and panelled work, which returns and is seen in elevation, between or in front of the parts which are in section—should take care to show all these lines in elevation, that being the correct way, and, in addition, they embellish their drawings. This particularly applies to panelled work.

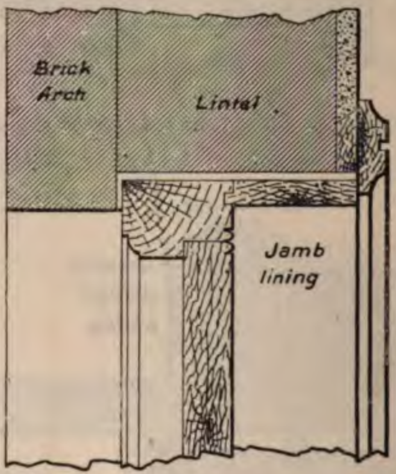


Fig. 611.
1½ Scale

Small scale elevations of the whole height of these jambs are given on figs. 613 and 614, the former being the plan and the latter the panelled linings, the rails of which should always correspond and be in true line with the panels of the door—*i.e.*, a door three panels high should have linings

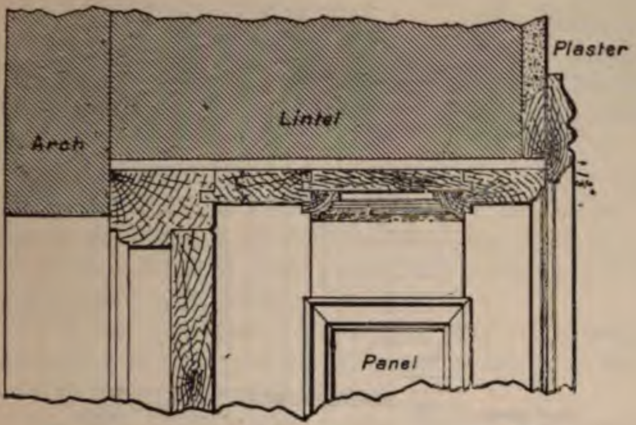


Fig. 612.
SECTION 1½" Scale

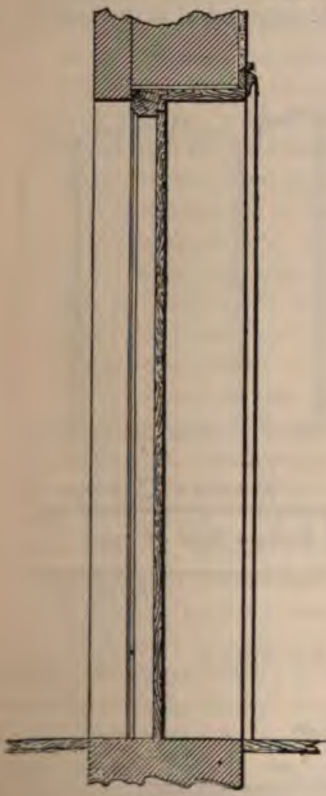


Fig. 613

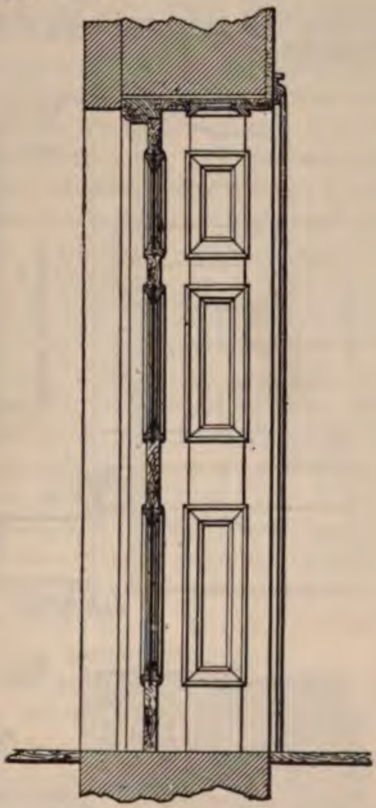
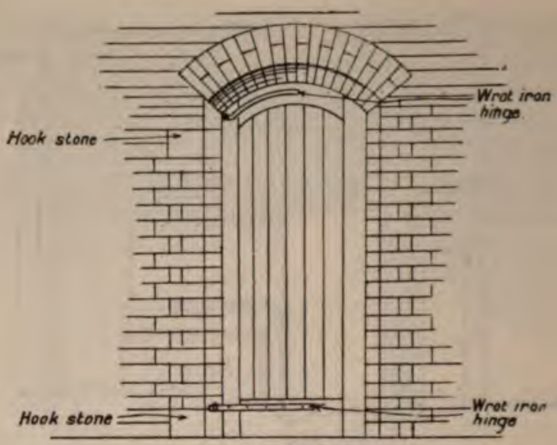


Fig. 614

½" Scale



Elevation
Fig 615. ⅛" Scale

three panels high, each panel being of the same height as those on the doo
to correspond.

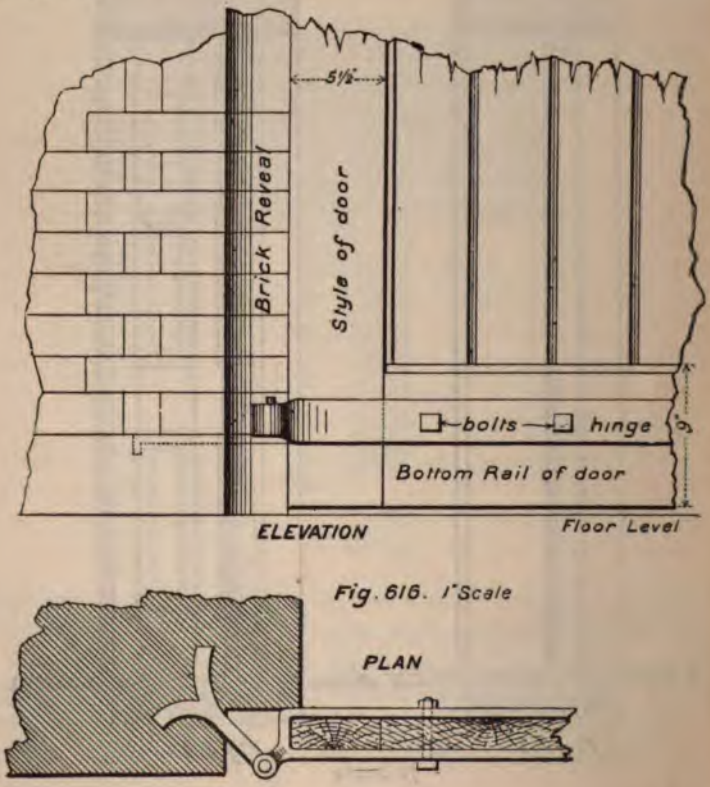


Fig. 616. 1" Scale

In agricultural buildings door frames are seldom used, the doors being hung at top and bottom by wrought-iron band-hinges, on to hooks which are secured to stones built in the jambs. Fig. 615 is a small elevation, and fig. 616 enlarged plans and sections, with details of the hooks, etc.

The hooks, otherwise called *crooks*, are usually used in pairs, and sometimes the top crook (or hook) is reversed, so that the pin of each points towards the other, to prevent the door being lifted off them, in which case the door has to be put in position before the upper band-hinge is attached, or bolted to the framing of the door.

Another method to prevent the door being lifted off its hinges, when hung externally, is to screw the end of the pin of the crook, and put on a nut, which should be permanently fixed.

When very large doors or gates are a necessity, it is very much better to screw the hinge to the lower edge of the bottom rail of the door with a conical pointed projection on the underside, instead of the knuckle to go over the pin; and this cone is made to work in a gun-metal socket, which is leaded into a special stone, fixed a small distance above the level of the threshold or top step immediately under the door, so that the door may swing or spin (as it were) on this cone. In this case it is always advisable to strengthen the band, supporting the door, by means of lugs or ears welded on either side, so that the thickness of the door is grasped by them. They should be at least nine inches high and every eighteen inches along the band-hinge, with a minimum of three pairs. It is needless to say these lugs should be bolted together through the door, and the face of them should be flush with framing; otherwise they will form a ledge or cup for the wet, and cause the bottom of the door to rot.

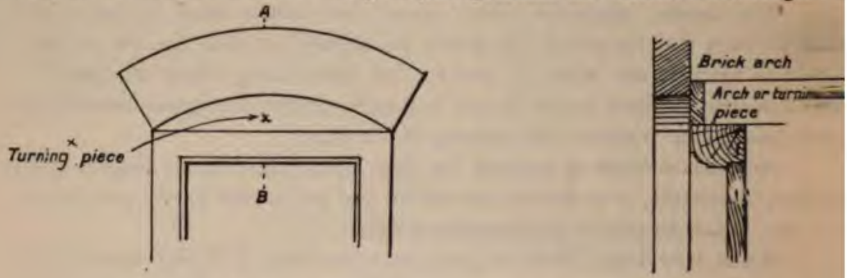
The knuckle and pin of the upper hinge must be perfectly perpendicular over the centre of the cone to render proper and easy working without undue pressure on particular parts; and the hanging style should be much wider than usual, so that it will have more strength to keep the door from sagging towards the closing or meeting styles.

If this principle of "centre hanging" or "on points" were more extensively used we should have less sagging of doors to contend with, especially with regard to the best doors, and even window shutters in first-class work, for the principle can be applied to the top and bottom of framings, similarly to "door springs," to great advantage.

Before leaving the subject of door frames mention must be made of the practice of using straight door frame heads in arched openings, and nailing a thin *turning piece* or arch piece on to the top of the frame, so as to fill up the space above to the outline of the arch, as fig. 617.

Doors.—Doors are wooden framings, hung to frames or doorcases, or on hooks, in external positions, and to casings or linings, internally. No door should ever be less than 2 feet 9 inches in width, 6 feet 9 inche in height, and 1½ inches in thickness.

Ledged Doors are the first and simplest form of door, consistin only of beaded or V-jointed match boarding, nailed to deal ledges, generally three inches in width. Fig. 617A represents the outside of a ledge



Elevation Fig 617 Section

door, and fig. 618 the inside, X X X being the ledges, which are oft chamfered on all arrises, as shown by the double line. A plan is give on fig. 619, and an enlargement of the section at the ledge, fig. 620.

They are hung to the frames by iron hinges, called *cross-garnets* or T-hinges (from their shape), fixed at top and bottom to door and frame, and are fastened by Norfolk thumb latches, and locked by cased stock

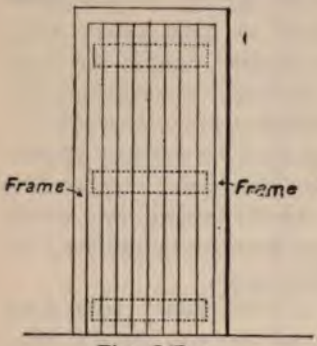


Fig. 617 A
Elevation

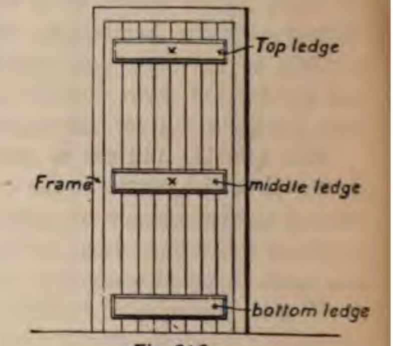


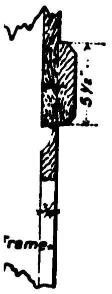
Fig. 618
Elevation

locks with a hollow box staple, X, fixed on the frame to take the bolt of the lock, as fig. 621. In the North these are called *Batten* doors.

N.B.—If the door frame is not rebated out to the thickness of the boarding and ledges, blocks have to be fixed on to the frames to make the fixing on the frames the same level as the ledges of the door.

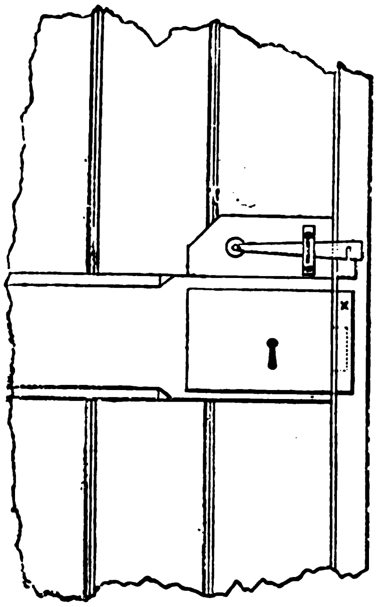
The **Ledged and Braced Door** is a stage higher than the ledged door, being braced up, as the name implies; the only noticeable difference being at the back, where the braces—whereof the object is to keep door from hanging down from its hinges—are seen. Fig. 622 gives levation of the back, from which the nature and difference of the door

Plan
g. 619.



ction
620. 1"Scale

¼"Scale



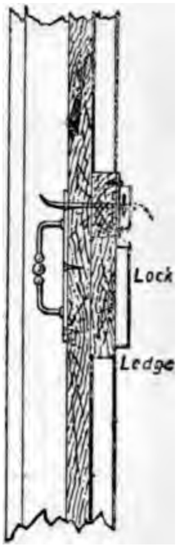


Fig. 621. 1½"Scale

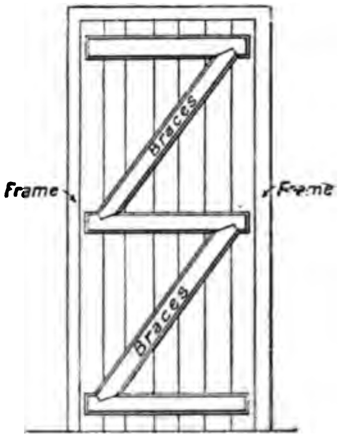


Fig. 622 ½"Scale

mpared with the plain ledged door) can be understood. The fasten- etc., are precisely similar to those used for ledged doors.

.B.—It must be borne in mind that these braces, to effect their , must incline upwards from the jamb to which the door is hung.

The **Framed and Braced** or **Framed Ledged and Braced** consists of a piece of framing, the size of the opening between the r of the door frame, with a middle or lock rail and braces (like the doo named) in addition, to strengthen the framing; the whole being fil with match boarding, as fig. 623.

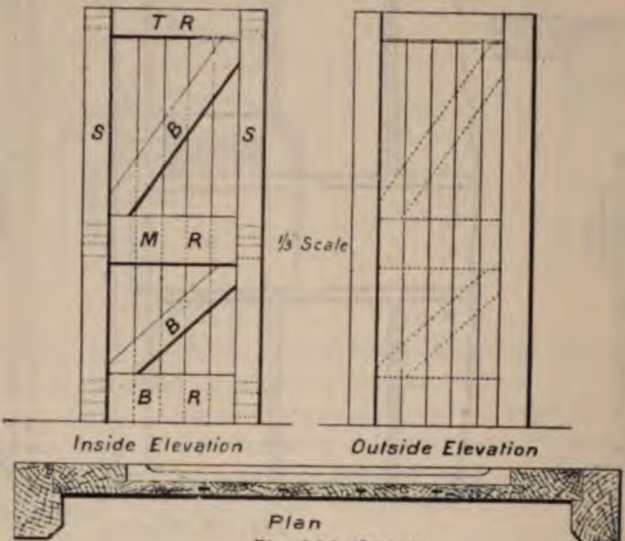


Fig. 623 1" Scale

Before going into the detail of this kind of door it will be as w impress upon the student that all continuous upright framings are *styles*, and the cross or horizontal pieces ***rails.***

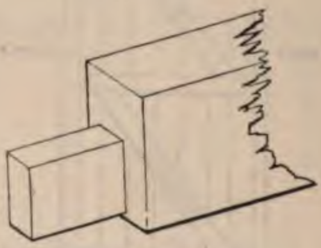


Fig. 624

The rails are tenoned and wedged into the styles in the usual w previously explained, the top rail tenon being as fig. 624, and the loc bottom rails (being the thickness of the boards less in thickness) bare-faced tenons, as fig. 537, but two tenons in height, on account o depth as compared with the top rail.

All styles are generally 4½ inches wide, lock and bottom rails 9 inches deep, and the top rail only 4½ inches; therefore, in a door 2 inches thick, the styles and top rail are 4½ inches × 2 inches, but the lock and bottom rails, to which the boarding between the styles and below the top rail is secured, are 9 inches × 1 inch, in cases where 1-inch boarding is used,

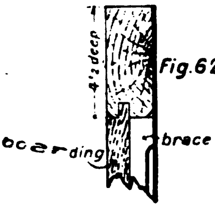


Fig. 625

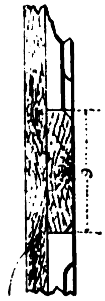


Fig. 626

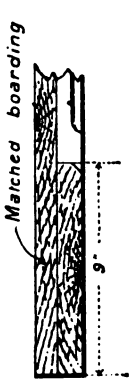


Fig. 627 Section

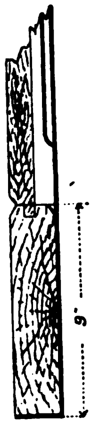


Fig. 628 Section

and 1¼ inch with ¾-inch boards—the two thicknesses, in each case, making up the 2 inches of the door.

The detailed section of the top rail, showing how the boards are secured to it, is as fig. 625; that of the lock rail as fig. 626; and the bottom rail, where the boards run through, as fig. 627; but in cases where a flush bottom rail is used, the section is as fig. 628.

Fig. 629 explains the joint at the styles.

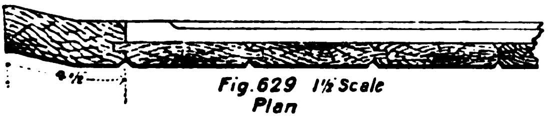


Fig. 629 1½" Scale
Plan

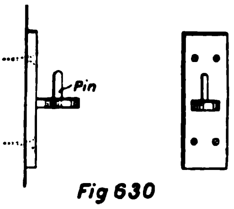


Fig 630

The fastenings used are just the same as for the ledged doors, with the exception that sometimes "band-hinges" are used instead of "cross garnets," the hinges being bolted to the door front and hung on to plate hooks, as fig. 630, screwed to the frames; or hook stones are substituted, doing away with the frames (*vide* fig. 616).

To impart a lighter appearance to the framing of these doors, the styles, rails, and braces are often stop-chamfered on all edges, the elevation of the joint at the lock rail next the hanging style then appearing as fig. 631.

Framed and Ledged Doors are similar in all respects to the last-named, with the only exception that, as their name implies, they have no braces.

Fanlights.—Some internal as well as external doors are made with transoms and fanlights over them, to give additional and regular light as fig. 632, X being the fanlight, which can be either fixed, or hung on butts or centres.

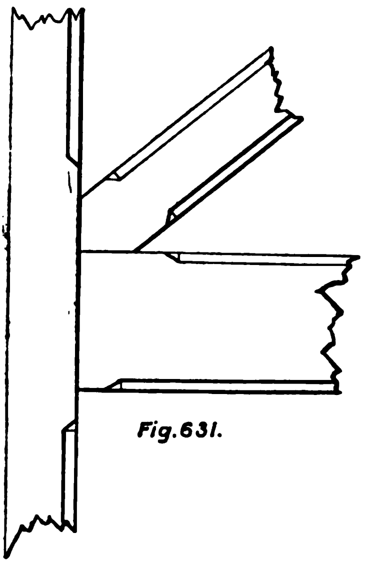
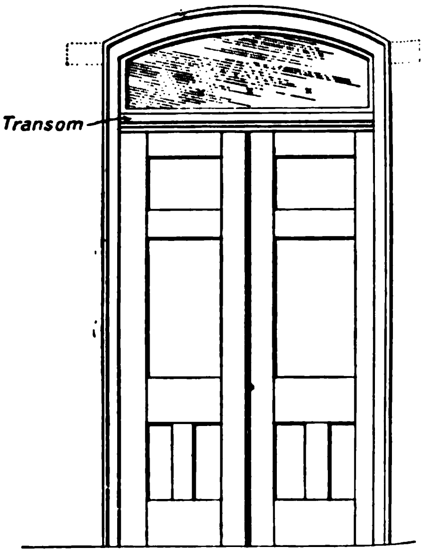


Fig. 631.

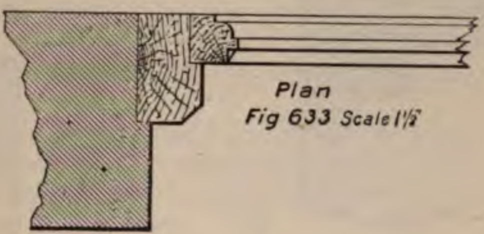


External Door with Fanlight
Fig. 632. 1/15 Scale

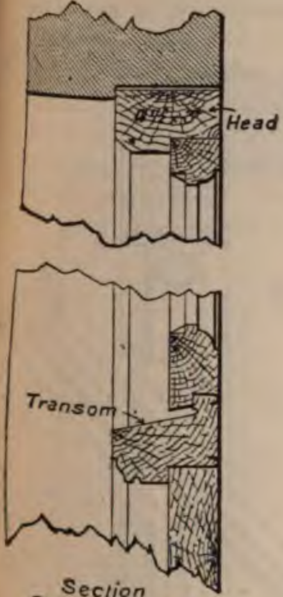
The fanlight itself consists of a piece of skeleton framing, similar to a glazed sash, with or without bars. The transom, more or less intricate in section, acts as a head to the door frame, and sill to the fanlight; being framed—by mortise and tenon joints—into the jambs, the head of the fanlight frame is similar to that for the head of the door, which has now been superseded by the transom.

Fig. 633 represents the jamb, head, and sill, with transom, of a fixed fanlight, a close examination of which will show all that is required for the purpose.

The styles and head of the fanlight are generally square, 1¾ inches or 2 inches, as the thickness of the fanlight and rebate on the frame. They may be of any section, ovolo-moulded (fig. 634); chamfered (fig. 635); lamb's-tongue moulded (fig. 636); or of any other design; but the glass must always be put in from the outside. Where putty is used it is always the best, and renders it the more water and wind-tight as the weather presses the glass against the rebate, as fig. 637.



Plan
Fig 633 Scale 1½"



Section
Fig. 633. 1½" Scale

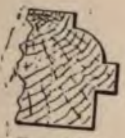


Fig. 634

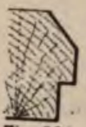


Fig 635

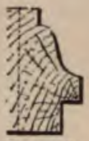


Fig 636

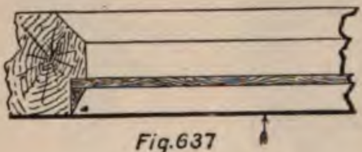


Fig. 637

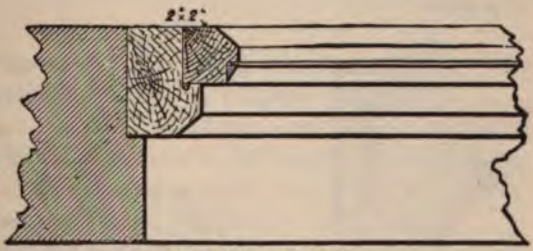


Fig. 639. 1½" Scale
Plan

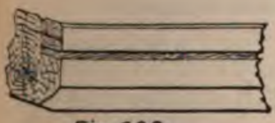
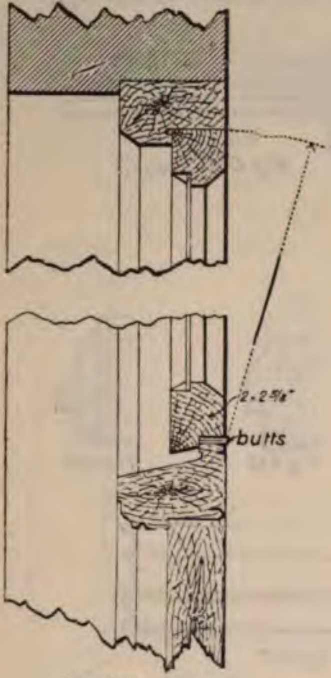


Fig. 638

Occasionally, however, when loose beads are used, the glass is put in from the inside, as fig. 638, but never with putty. The mouldings certainly look better outside in contrast to the putty, but the work is never so good.

A *hopper fanlight—i.e.*, one to open inwards, hung on butts to the transom—is illustrated at fig. 639, which explains itself.

Fanlights are seldom made to open outwards, because they ar apt to help the rain to come into the house, as can be imagined fig. 640.



Section
Fig. 639

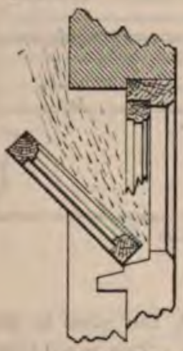
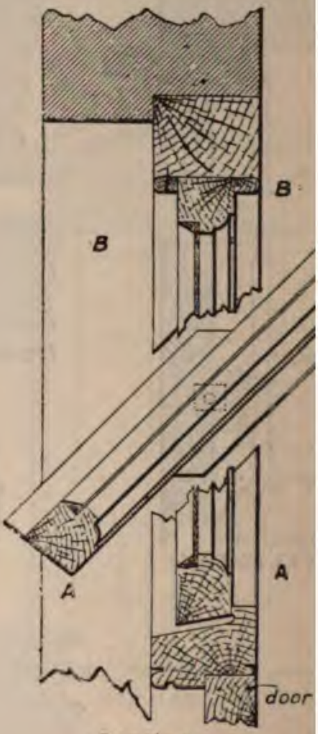
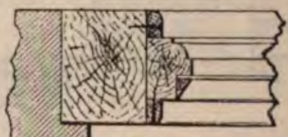


Fig. 640



Section
Fig. 641 Scale 1½"



Plan of Jamb at A.A.

A fanlight *hung on centres* is represented by fig. 641, from the principles may be gathered. The jambs have a solid bead c lower part of their height (something less than the half) inside, a the upper part outside; with loose beads planted on the style of the fanlight, in reverse fashion; mitre-cut to fit each other—*i.e.*, each loose bead into the corresponding solid bead on the jamb—both inside and outside, when closed.

This is done to allow the swing-fanlight to open outwards at the bottom and inwards at the top, revolving on pivots which fit into slots fixed on each jamb.

These are also called *pivoted* fanlights, from the manner of hanging them on pivots, as fig. 642.

The advantage of pivoted or "centre-hung" fanlights is that, being out of reach, so to speak, they can be easily opened and closed by means of cords and pulleys. If the fanlight have the pivots fixed a little above he centre of its height it will close of itself.

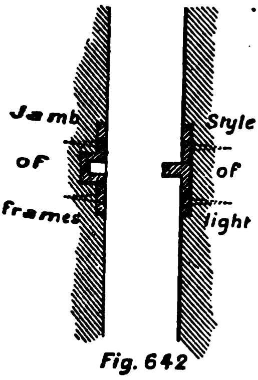


Fig. 642

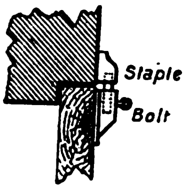


Fig. 643

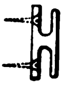


Fig. 644.

Should the fanlights be divided into small squares, the bars used are similar to those explained for sashes in Chapter XVIII.

Hopper fanlights (fig. 639) are secured by small spring fasteners, fixed to the top rail of the fanlight, with a box staple, to receive the spring bolt, fixed on the head of the frame, as fig. 643. The ring serves to pull the bolt back when the light is required to be opened.

Pivoted lights can be secured properly by means of the cords, which may be tied over belaying hooks (fig. 644) screwed to the frame of the door, or to the linings.

Panelled Doors.—This kind of door is the most general in ordinary use, and consists of a framing, made up of narrow pieces, mortised and tenoned together, and grooved in the inside to receive the panels.

Fig. 645 represents the plan and elevation of the skeleton of a four-panelled door, fig. 646 those of a five-panelled door, and fig. 647 those of a six-panelled door.

S S are the styles, the one with the butts on being called th hanging style, and the other the closing style. Styles always ru through the whole height, and are really the foundation of the complet framing, the other members being directly or indirectly connected t them.

M M are the *muntins* or *muntings*, which are tenoned, at top and bottom, about 2 inches into the rails, as, for obvious reasons, they cannot be wedged.

T R is the top rail, which is tenoned into the styles.

L R is the lock or middle rail, the top of which should always be 3 feet 2 inches above the floor line, that being the acknowledged height of convenience for the handles of the locks.

B R is the bottom rail; and F R, when used, the frieze rail; P represents the panels, which are sometimes distinguished as "top," "bottom," or "middle" panels, according to position; and F P are the frieze panels.

The door, fig. 645, is hung with one pair of butts, which should be of wrought-iron, either 3 inches or 4 inches in length; the lock is a rim-lock, which, though on the same principle, is of a better kind than the ordinary stock-lock—viz., a projecting lock, screwed on to the face of the framing, the bolt, when turned, going into a box staple secured to the jamb of the frame or lining.

The five and six-panelled doors, figs. 646 and 647, are hung with 1½ pairs of butts, on account of their increased size, while they are secured by a mortise-lock, which is sunk into the style and part of the lock-rail, as shown by dotted lines.

In addition to the *furniture*, as the handles or knobs, etc., are commonly called, it will be noticed that these doors have what are called *finger-plates* screwed on to the styles above and below the lock.

Fig. 648 will give the student an idea how a door is put together, the example being a five-panelled door.

It will be seen that the styles are made with horns, X X, 1½ inches longer than the size of the door, at top and bottom, to give the workmen something to knock the styles off by while framing, and allow of more substance to withstand the driving home of the wedges at top and bottom.

Where the doors are 2 inches or more in thickness, all rails, etc., must be double-tenoned; and under any circumstances all lock-rails must be double-tenoned into the closing style when mortise locks are to be used.

Before entering into the details of the various modes by which the skeleton framing of the door is ornamented, it must be impressed on the student that all panelled doors can be treated in the same manner with class of work on both sides, or a different one on each side. For ance, a four, five, or six-panelled door can be either square-framed

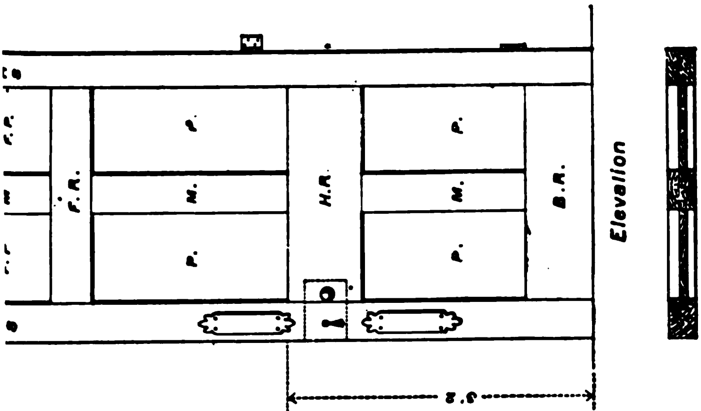


Fig. 647.

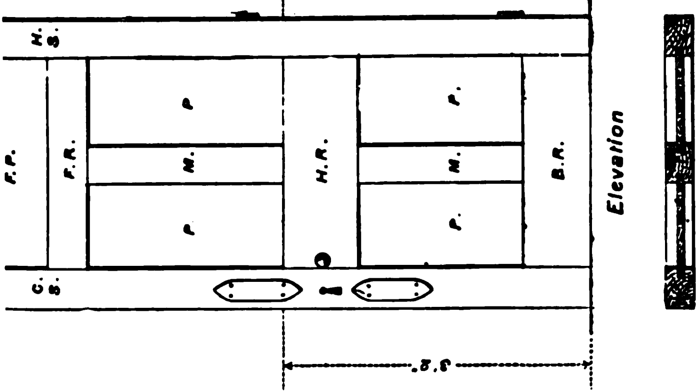


Fig. 646.
½ Scale

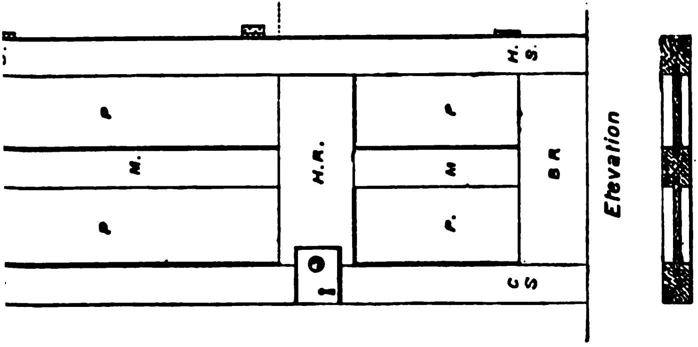


Fig. 645.

ides, as fig. 649; moulded both sides, as fig. 650; or square-framed de and moulded the other, as fig. 651.

uare-framed consists of the panels being left in squa
:t, left as the skeleton framing. Fig. 649 represents a (
:d on each side.

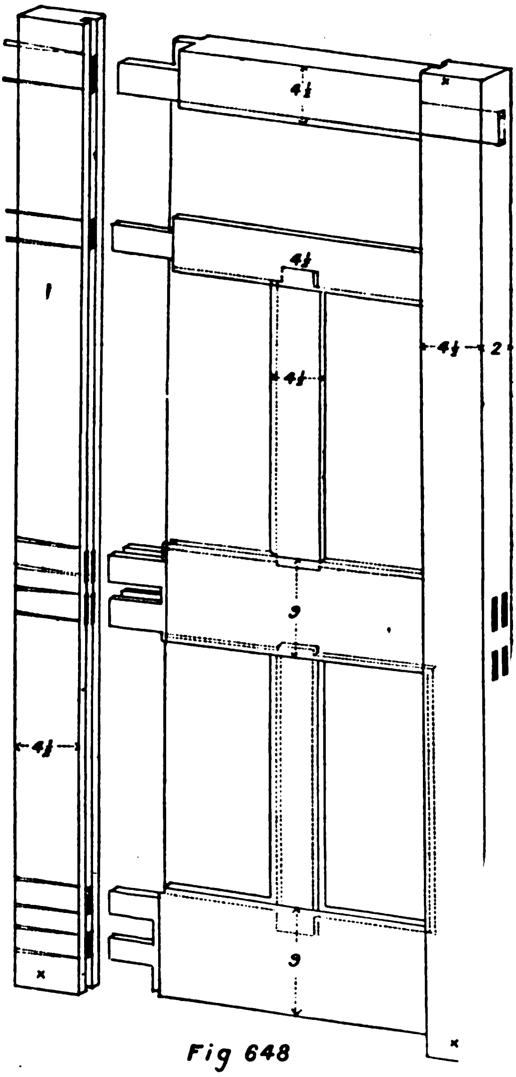


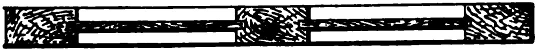
Fig 648

Moulded both sides is the term used when m(
round the panels (fig 650), whether they be "st
mouldings, as explained in Chapter XVI.

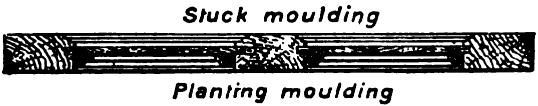
Square-framed and moulded is a combination of the last two, one kind being on each side.

Bead butt and square is as fig. 652, the beads running up beside the styles, and butting up against the rails. It will be noticed that the panels in this kind of door are thicker, which is an advantage in external doors.

Square & Framed Panels·



Plan
Fig. 649. 1"Scale



Plan
Fig. 650. 1"Scale

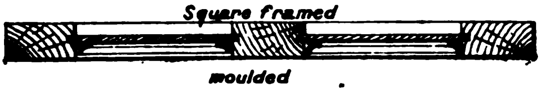


Fig 651. 1"Scale

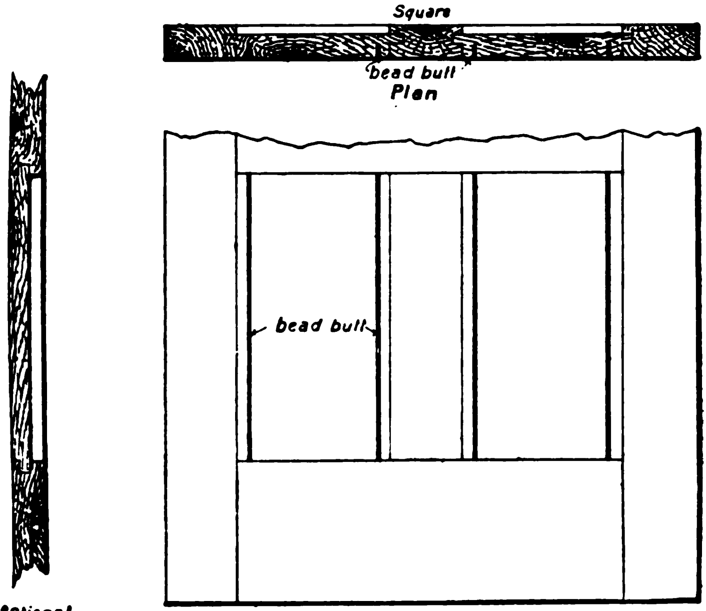


Fig. 652. 1"Scale

Bead flush and square has the bead mitred round inside the panel instead of only on two sides, and butting against the rails. The plan is precisely the same as fig. 652, the difference only being detected on the drawings upon the elevation and vertical section (see fig. 653); and comparing them with fig. 652, it will be noted that the bead is shown on the sectional elevation in a "bead-flush" door, but not in the "bead butt."

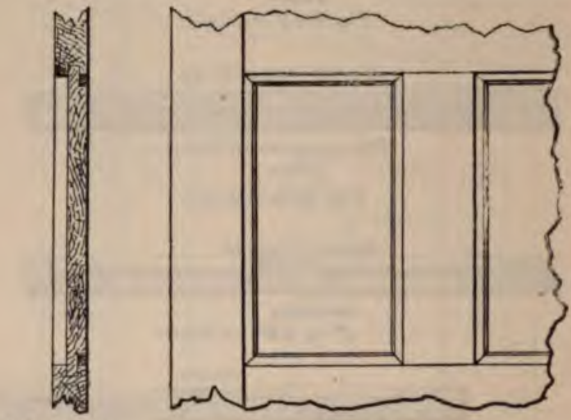


Fig. 653. 1" Scale

The two kinds of doors last named are often made moulded instead of square on the inside, being "bead butt and moulded," or "bead flush and moulded." The beaded work is seldom put inside, being most suitable for outside, and having a more substantial and strong appearance, unsuitable for internal effect.

Chamfered and square is as fig. 654, and requires no further explanation, except that the chamfers are worked "on the solid"—*i.e.*, of the framing itself.

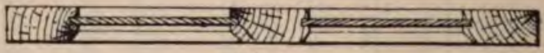
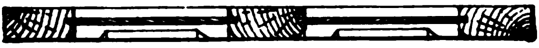


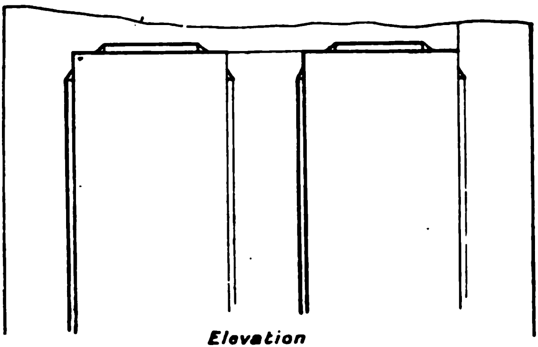
Fig 654. 1" Scale

Stop-chamfered is as fig. 655, the elevation of the panels being as shown.

Bolection-moulded doors are on plan as fig. 656, and on elevation as fig. 657; whereon it will be noticed that the lines of the framing are within the outsides of the moulding, which is the proper way to show a bolection moulding in elevation.



Plan



Elevation

Fig 655. 1" Scale

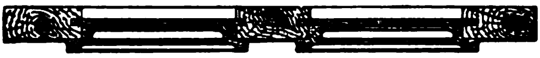


Fig. 656

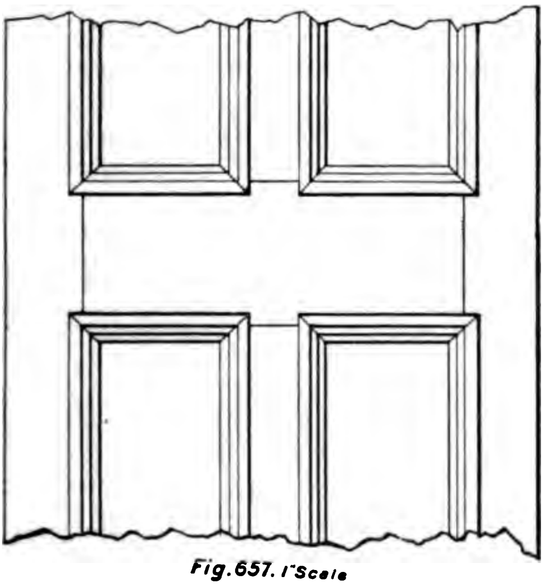


Fig. 657. 1" Scale

Often in addition to these mouldings—which are connected to the sides of the framing, and really enclose the panels—the panels themselves are more or less ornamented, the most general methods being the following:—

Raised panels, as fig. 658, from which it will be seen that the panels are thicker in the centre being raised up from the usual face which goes into the groove of the styles and rails.

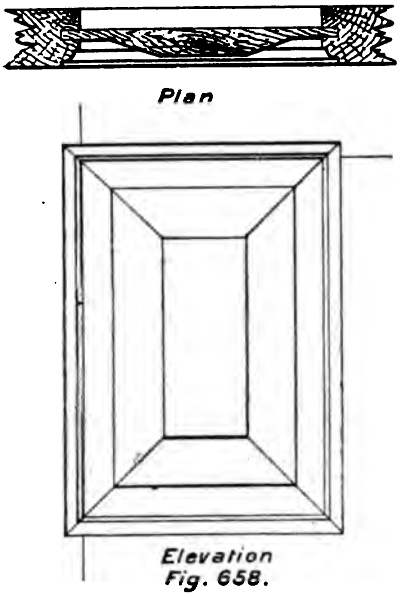


Fig. 658.

Raised and sunk appear the same, in front elevation, as the last; but, before the bevel starts from the face of the panel, it is first sunk about $\frac{1}{8}$th of an inch, as X X on fig. 659.

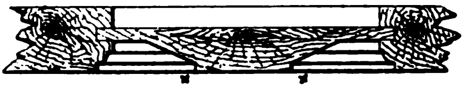


Fig. 659 1½" Scale

Moulded, raised, and sunk panels are yet a step higher, the edge of the raised portion being moulded, as fig. 660, which carries a double line in elevation.

Linen panels are occasionally used in the best kind of work, the face of the panel being moulded and carved to represent a roll of linen twisted about (fig. 661).

Miscellaneous Doors.—Some doors, called *sash doors*, are made with the top part of them prepared for glass panels, in which cases the styles are often diminished at the lock or middle rail, as at X, fig. 662.

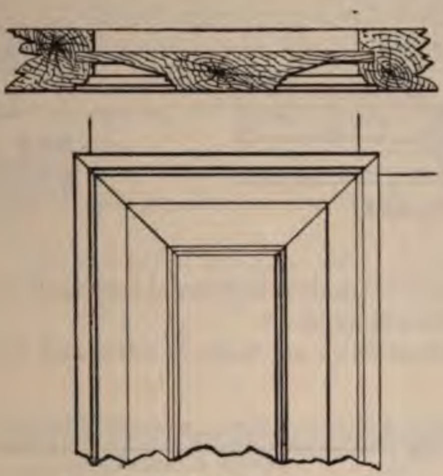
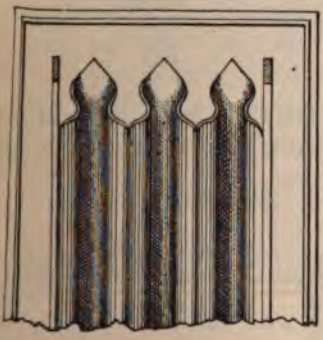
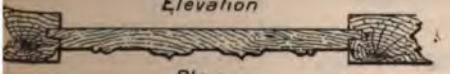


Fig. 660. 1½" Scale



Elevation



Plan
Fig. 661.

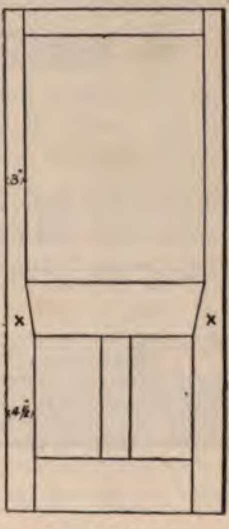


Fig. 662 3/8" Scale

s is done both for effect, and to allow of more area of glass, which is red within the framing by loose beads mitring round the panels and wed to the framing after the glass is in.

Fig. 663 is an enlarged plan of the style, showing the glass and
of fixing. The styles of this kind of door are often called *gun-stock* st
from the shape which results from the diminution.

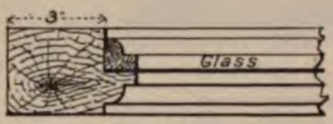


Fig. 663.

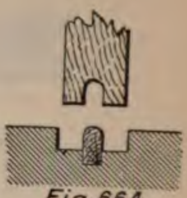


Fig. 664.

Dwarf doors is a name given to doors of very small area, principal
cisterns, cupboards, and trapdoors.

Jib doors are those which are made to correspond in appearance

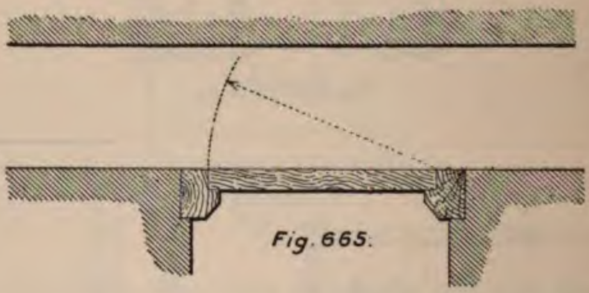


Fig. 665.

the walls of a room, having the same finishings, in the shape of skirtings, dadoes, chair, and picture rails, or cornices, fixed to them as to the walls. They are out of date now, and seldom used.

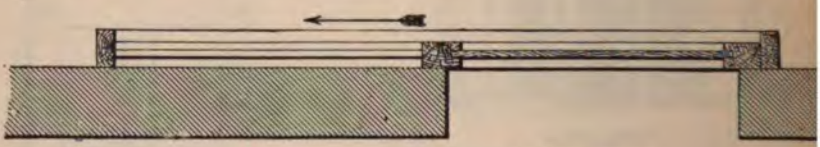


Fig. 666 ½" Scale

Sliding doors (when double) are made in two portions, which run pa
each other on wheels when required to open. The wheels, which ma
either be fixed to the top or bottom of the doors (figs. 668 and 669), ha
a hollow margin in the centre, which grips an iron or hard wood gui

(fig. 664) running past the openings, the whole width of the doors, to keep them in position.

This class of door is suitable for goods sheds, fittings, and other situations where there is not room for a door to open on its hinges, as fig. 665.

To overcome this difficulty the sliding door is used either double or single, according to the width of the framing and spaces at its sides (fig. 666).

Fig. 667 shows an opening with narrow sides, which necessitates the door being in two halves.

Figs. 668 and 669 show, respectively, sliding doors, with wheels on a runner overhead, and on a runner underneath, with guides to suit the alternate methods.

Folding doors are those which, being too wide to be hung to one jamb, are divided into two parts, each hung to a jamb, right and left, and meeting in the centre, as fig. 670. Each of the half-doors is hung with butts to the jamb, and one "leaf" or "fold" is fastened by bolts at top and bottom, into sockets fixed to the head of the frame or linings, and to the floor. The other leaf is secured with either a rim or mortise lock (as before described), but the latter has to be rebated to suit the section of the closing style of the door.

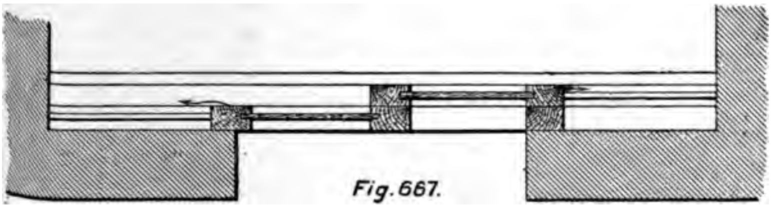


Fig. 667.

They are made in the same way as other doors, the meeting styles (as they are called) at X being rebated, as fig. 671, to form a joint; and in best work this is more or less checked to prevent the ingress of draughts and damp, as fig. 672.

The jambs of these and other kinds of doors and frames are also often checked out for the same reasons (fig. 673), but it is better to leave a hollow on the frame, as fig. 674, and have no projection on the style of the door, which has been proved to suck or draw in the rain in windy weather.

Double-margined doors are imitation folding doors. The door is hung in one width, with a bead worked on the middle from top to bottom, to make it appear as if it were made in two parts.

Internal doors have "linings" or casings, which can be either plain or panelled, according to the thickness of the walls they are in for the cases.

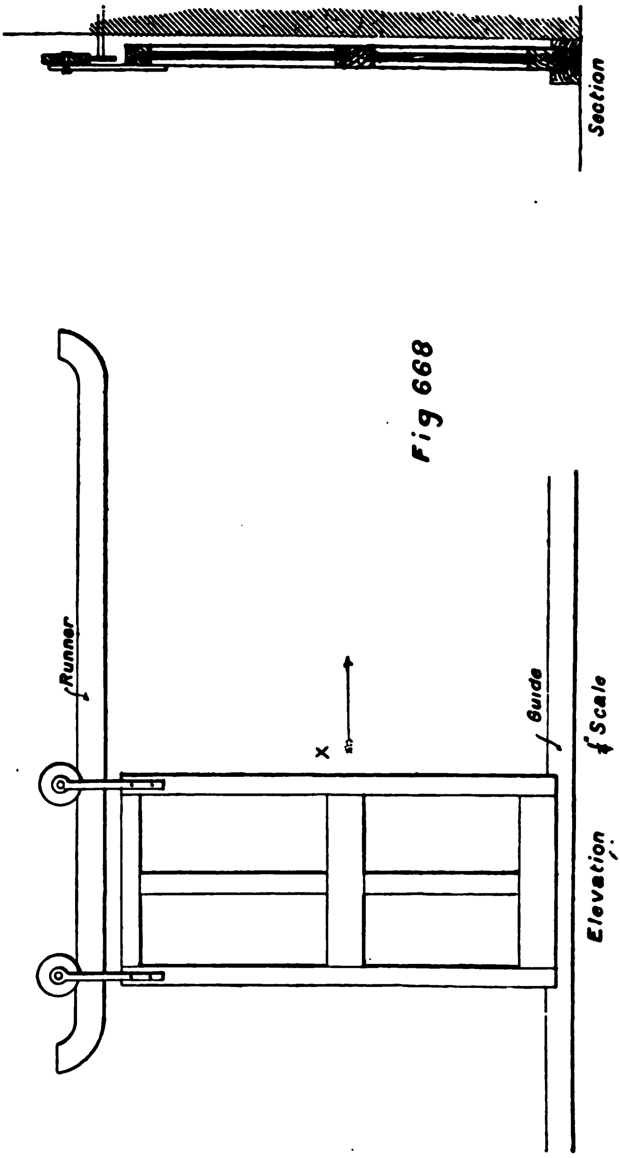
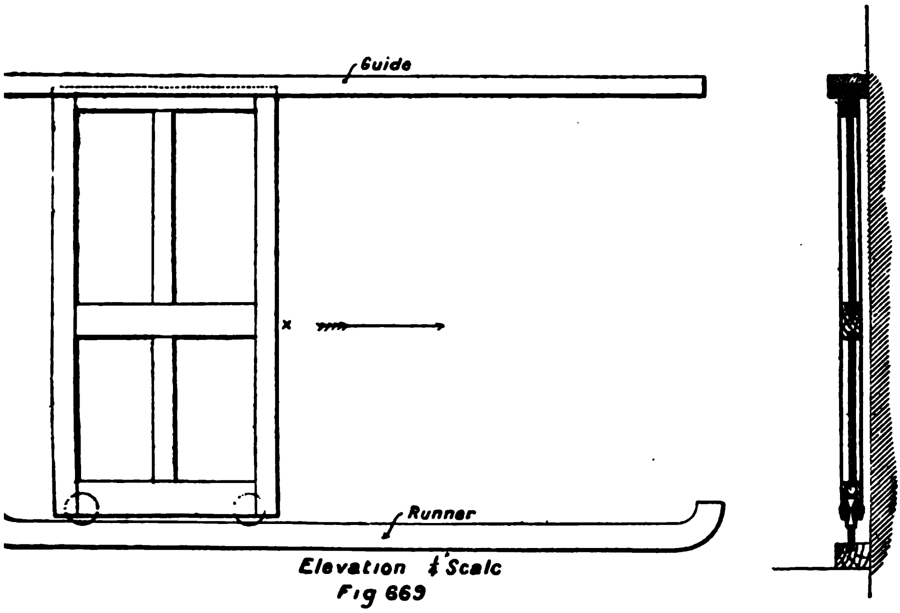


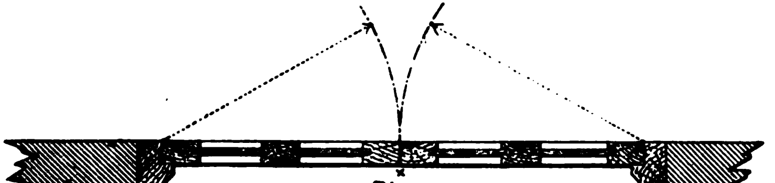
Fig 668

Plain casings are used for doors in 4½-inch, 9-inch, and sometimes 14-inch brick or corresponding stone walls. A rebate on the casing an inch in depth, around the three sides of the door, regulates the size of



Elevation ¼ Scale
Fig 669

Section



Plan
Fig. 670 ½" Scale

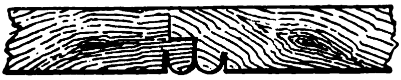
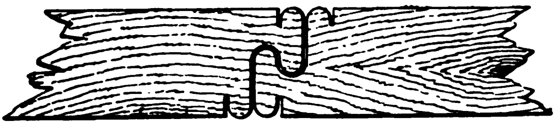


Fig. 671.



Hook rebate
Fig. 672.

the casing. Thus for a door 2 feet 9 inches × 6 feet 9 inches, the casings must be 2 feet 9 inches between the rebates in width, and 6 feet 9 inches between floor and rebate in height. Their width is regulated by thickness of the walls *plus* the plastering, if any, on each side. A ca for a 4½-inch wall should be 4½ inches, *plus* two ¾ inches for plasteri *i.e.*, 6 inches wide; and for a 9-inch wall it should be 10½ inches wide

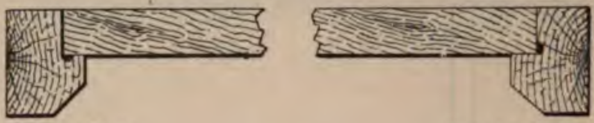

Closing Style
Hanging Style

Fig. 673.

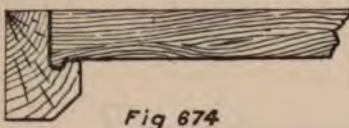


Fig 674

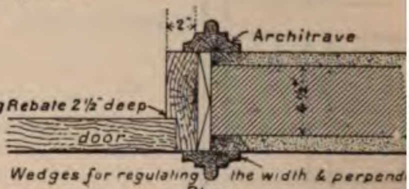
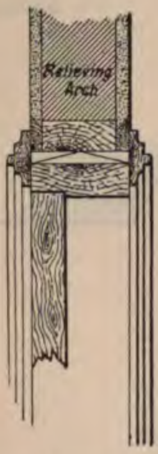
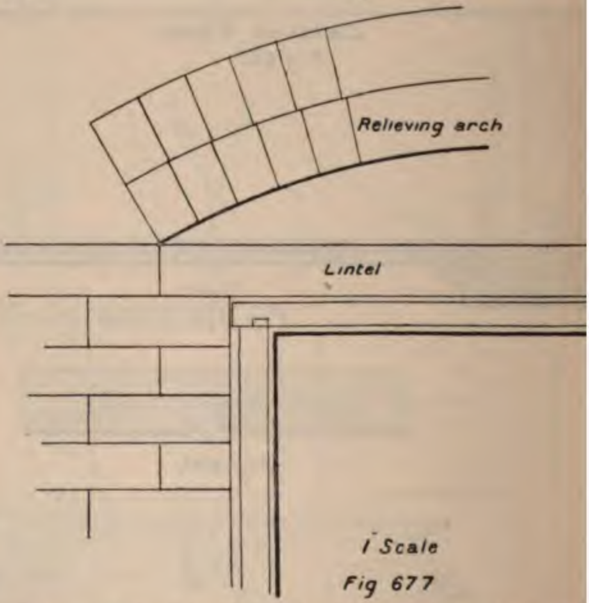


Fig. 675.



Section
Fig. 676. 1" Scale



1" Scale
Fig 677

Plain casings are generally 2 inches thick, and either single or dou rebated—the one being necessary for the door and the other accordin fancy and uniformity.

Fig. 675 represents the plan of one jamb of the casing for a 2- door in a 4½-inch wall, *single-rebated.*

Fig. 676 gives the section at the head showing the architraves on each side in elevation and section.

Fig. 677 shows a front view of part of a door lining or casing, with lintel and relieving arch, and rebate for doors, whereof fig. 678 is an enlarged view.

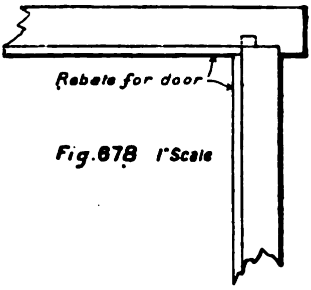
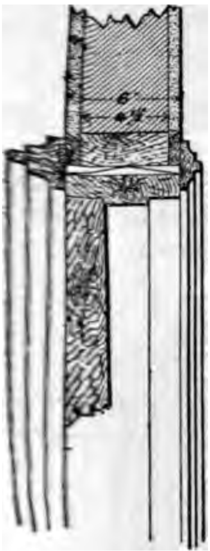
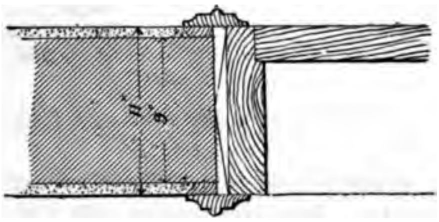


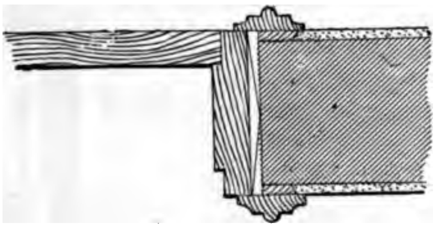
Fig. 678 1" Scale



Section
Fig. 679 1 Scale



Plan
Fig 680



Plan
Fig 681

Double-rebated casings have a rebate on the other edge, corresponding to that for the door; a 6-inch casing—*i.e.*, for a 4½-inch wall—being as fig. 679, which is a section through the head. It is needless to give the jamb; the student should be quite able to follow that out himself.

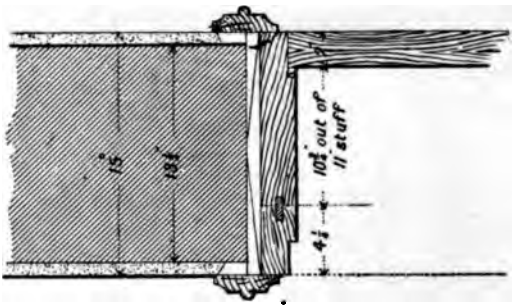
The "single and double-rebated" casings for 9-inch walls are similar to the last, but of course wider.

Fig. 680 represents the plan of a single, and fig. 681 that of a double-rebated casing for a 9-inch wall.

Those for 14-inch walls must, of course, be cross-tongued, having to be made out of two widths of stuff, 11 inches being the widest procurable.

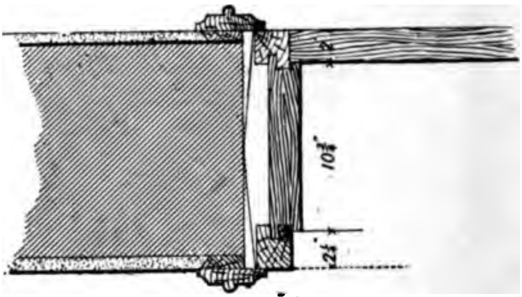
Fig. 682 is a plan of a cross-tongued double-rebated casing.

Occasionally, this cross-tonguing is superseded by framing on loose rebates on each side, as fig. 683, which has the advantage of not showing any crack if the joint gives, as would be seen with the cross-tonguing, as fig. 682.



Plan. 1" Scale
Fig 682

It is also a good plan to key them across their back with hard wood keys, to keep them from twisting; the keys being dovetailed in, as it were (see fig. 684), and driven home from the thick to the thin end.

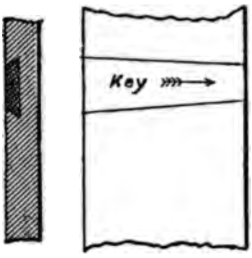


'lan 1" Scale
Fig 683

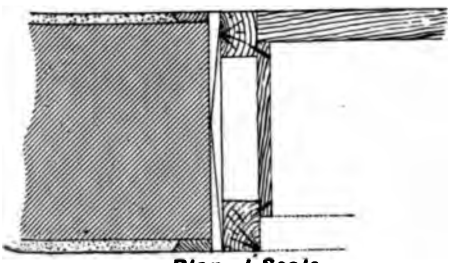
This difficulty is often obviated by using *skeleton casings*; but it should be noted that these can be, and are, often used for any other widths. They have the advantage of giving a firmer and better fixing for the hanging style of the door. The 1½-inch thickness, which the rebate left of a 2-inch casing or lining, was all too little and weak for hanging a large door to; whereas, with the skeleton casing and "loose" stop, we have always 2 inches to hang to, and without waste of stuff and extra cost, such as would be entailed if there had been 2-inch rebates, on plain linings.

Fig. 685 represents an enlarged plan, and fig. 686 a small elevation, of the jamb, before the rebate, or rather *stop* piece, is planted on its face to form the rebates.

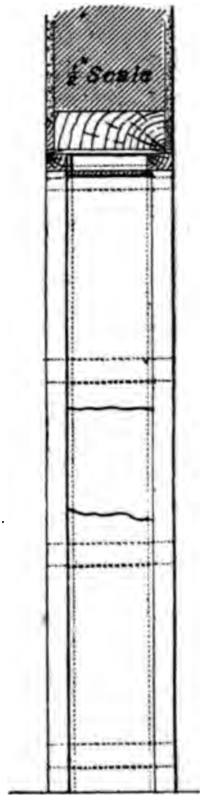
Panelled casings, as the name implies, are more ornamental than any of the last. Still they cannot be used for narrow casings; 11 inch even



Section Back
Fig 684



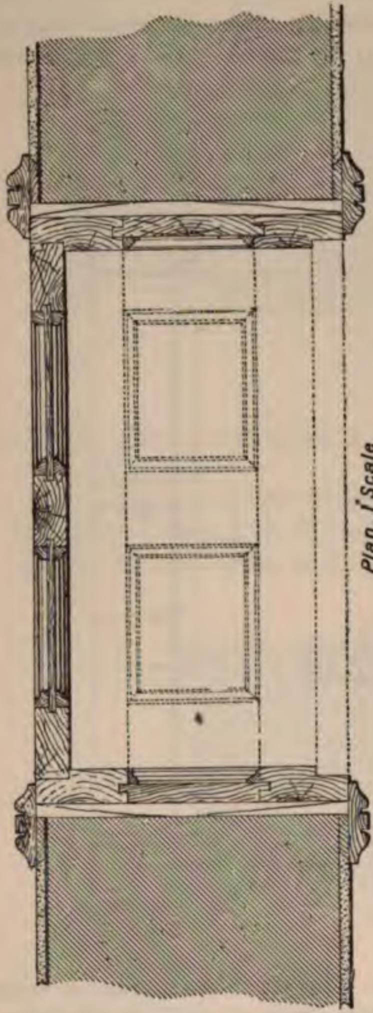
Plan 1" Scale
Fig 685



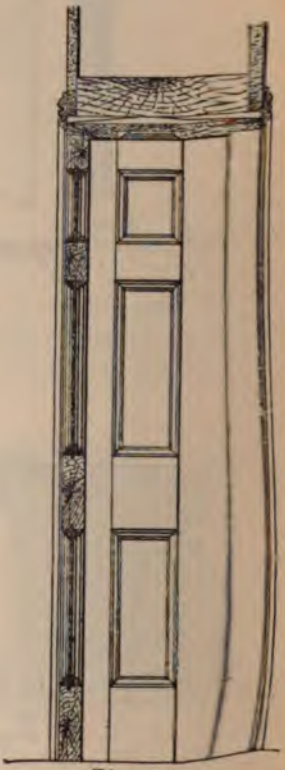
Sectional Elevation
Fig 686

ake the panels rather cramped up. The panels must range in height, tc., with the doors, those on the jambs by the panels of the door in eight, and those on the head according to the number of panels at the op of the door. It is always as well to show the top or "soffit" panelling, as it is termed, by dotted lines on the plan, as fig. 687, which gives a plan, etc., of panelled linings or casings for an 18-inch wall, and fig. 688 a smaller-scaled elevation.

From figs. 687 and 688 the student will gather that the door is 6-panelled, 3 in height and 2 wide; a 5 and frieze-panelled door would have had only 1 panel on the soffit where 2 are shown by dotted lines on the plan.



Plan. 1" Scale
Fig 687



Elevation
Fig. 688. ½ Scale

Oftentimes the rebates are what are called *loose* rebates, and they are sometimes beaded in addition, as fig. 689.

From the various illustrations, etc., given of linings or casings, the student will have noticed how important it is that the framed grounds round the doorway should be fixed to the gauge shown on fig. 591

ectly plumb on the face and sides; though the latter can sometimes :orrected by the wedges used to regulate and secure the proper line ie door casings.

Dadoes are wooden framings fixed to the walls around a room, either n ornament or for protection. They are usually about 1½ inches

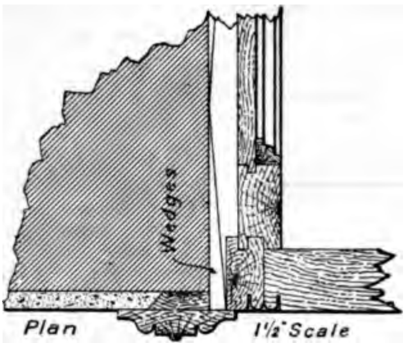


Fig. 689

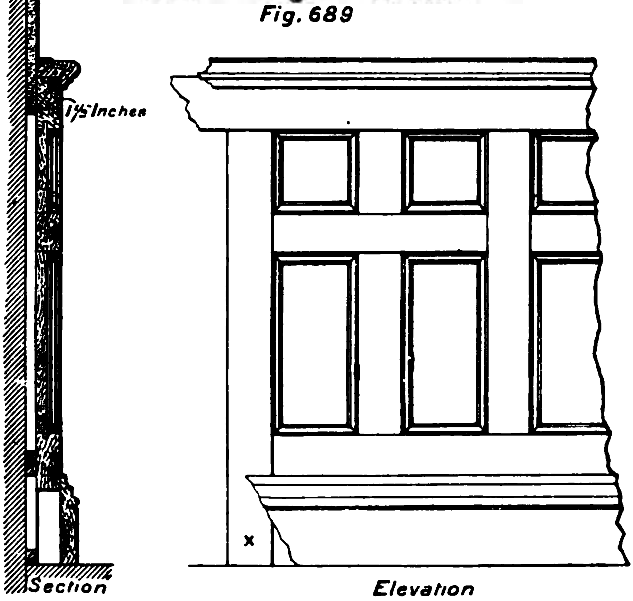


Fig. 690. ¾ Scale

iickness, and can be made of plain, cross-tongued, or any other ie various kinds of match-boarding; or, in better work, they are lled, and can be square-framed, moulded, chamfered, bolection-lded, bead flush, or with raised or other ornamental panels, as iined and illustrated for doors.

'hey are square at the back and fixed to grounds and backings plugged to the brick walls; but, to prevent damp, they should be painted at the back before being permanently fixed.

Fig. 690 represents a section and part elevation of a panelled dado with its belongings, X showing what is called a *leg*, being the end style, which runs down to the floor; between these legs the dado only goes just below the top of the skirting. There is no regulated height for dadoes; they vary according to taste and the number of panels in height. Of course, in match-boarded dadoes, the boards are fixed perpendicularly, and generally run down to the floor.

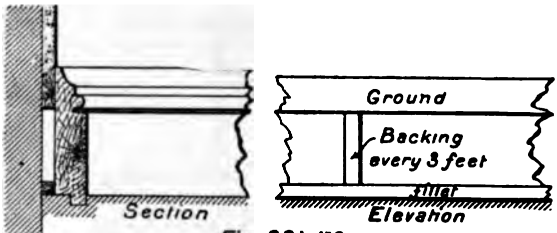


Fig. 691. 1"Scale

All internal angles of dadoes are tongued and grooved, and the external angles mitred and tongued, or formed with any other suitable joint, explained in Chapter XVI., to which please refer.

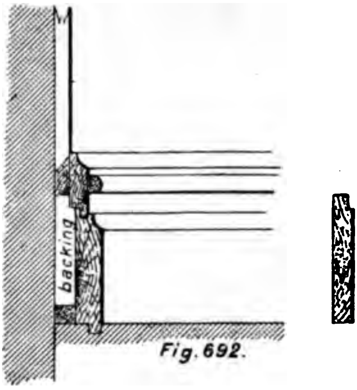


Fig. 692.

Skirtings are plain or moulded longitudinal boards, of various heights, fixed on grounds and backings to the walls at the floor line. In best work they are tongued into the floor, as fig. 691, which represents a moulded skirting with its fixings.

Internal angles are tongued with the mouldings scribed over each other, and the external angles are mitred only.

A *double skirting* consists of two or more members, as fig. 692, and enerally necessitates the backings being cut to the shape of the back f the complete skirtings, as fig. 692.

Chair rail is the name given to the longitudinal mouldings which

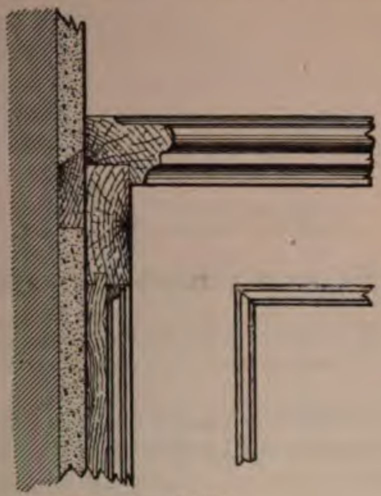


Fig. 693.

re fixed at the height of the tops of the backs of chairs, as a capping o dadoes, as in fig. 693; or to grounds on plaster walls, as fig. 694.

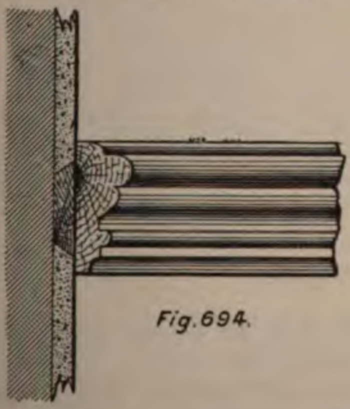


Fig. 694.

The chair rail is often called the "surbase," and the skirting the "plinth" or "base" of a dado.

Skirtings and dadoes are often made of plaster or cement, instead of wood; but these will be explained in Chapter XXI. on "Plastering," etc.

CHAPTER XVIII.

WINDOWS AND WINDOW FINISHINGS.

Sash, or Cased Frames—Solid Frames and Casements—Borrowed Lights—Window Finishings—Shutters.

Windows and Frames.—Window openings are filled in with two classes of joiner's framing—cased frames filled in with sashes, or solid frames with casements.

Sash Frames.—*Cased frames* are of two parts, as stated above, consisting of sashes, in one or more squares, with or without bars, suspended over pulleys by lines with regulated weights tied on at the other end, in boxings framed together as jambs. These jamb boxings are connected by a head at the top and sill at the bottom, forming a four-sided frame, within which the two sashes are enclosed.

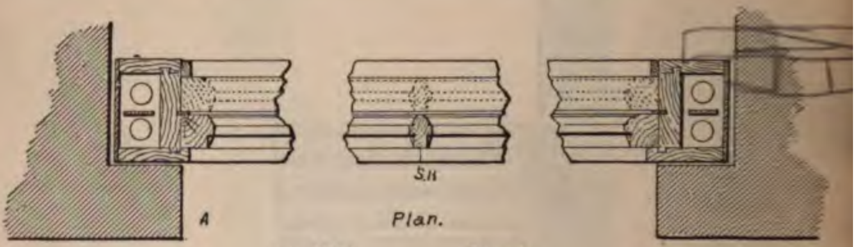


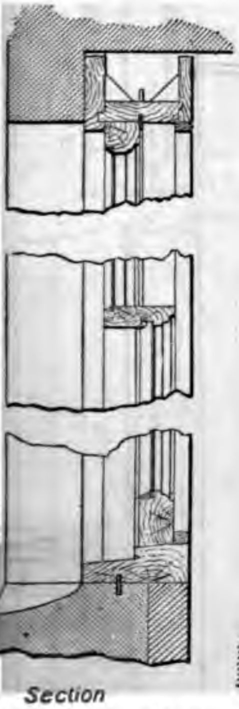
Fig. 695. 1" Scale.

Fig. 695 represents, to a small scale, the plan of a cased frame with its sashes; fig. 696 is a section of the same.

Figs. 697 and 698 are enlargements of the same, at the points marked A, B, C, and D, respectively; and the detailed parts are lettered as follows:—

P S, pulley style; P P, pocket piece; P H, pulley head—*i.e.*, head of style; S C, sash cord; W, weights; I L, inside lining; O L, outside lining; B L, back lining; P B, parting bead; P L, parting lath; T B, inside or stop bead; S, sill; B, blockings; S, styles of sashes; B R, bottom rail of sashes; M R, meeting rails of sashes; T R, top rail of sashes; S B, sash bar.

From the enlarged illustrations the student will have noticed that the thickness of the sashes, whether it be 1⅝, 1¾, 1⅞, 2, or 2¼ inches, regulates the thickness of the whole boxing. All the other usual sizes are figured, so that he should be able to apply the above to any thickness of sash.



Section

Fig. 696 1' Scale.

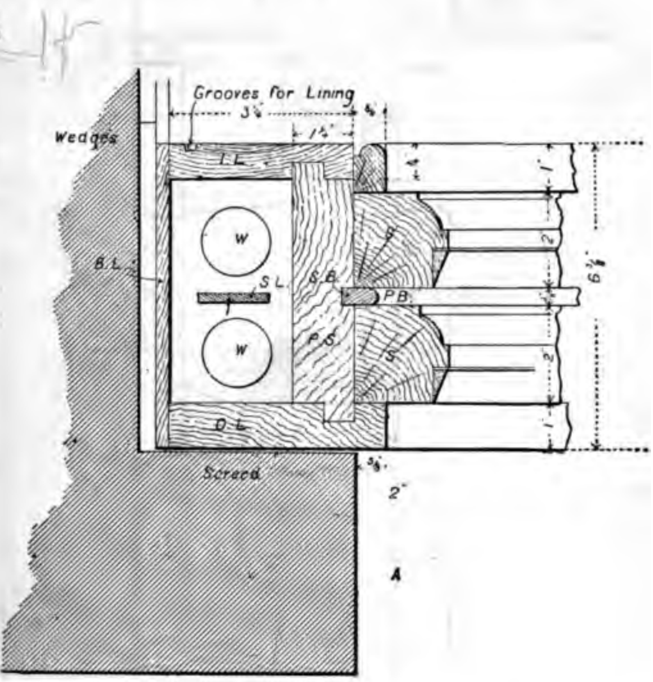


Fig. 697 Scale ¼ full size.

On fig. 697, the plan of the jamb, both sash styles are shown, though only the inner or bottom sash is really seen in its place when the section is taken below the meeting rail C, and that of the top or outside sash is only observed when a section is made above the meeting rails.

It will also be noticed that the two weights are shown in the boxings. This sash-frame is supposed to be *double-hung*,—*i.e.*, both sashes are suspended by the cords over the pulleys, and weighted, so that they can be regulated when neither open nor shut. If the sashes were *single-hung* only one weight should be shown in each jamb on the same side of the

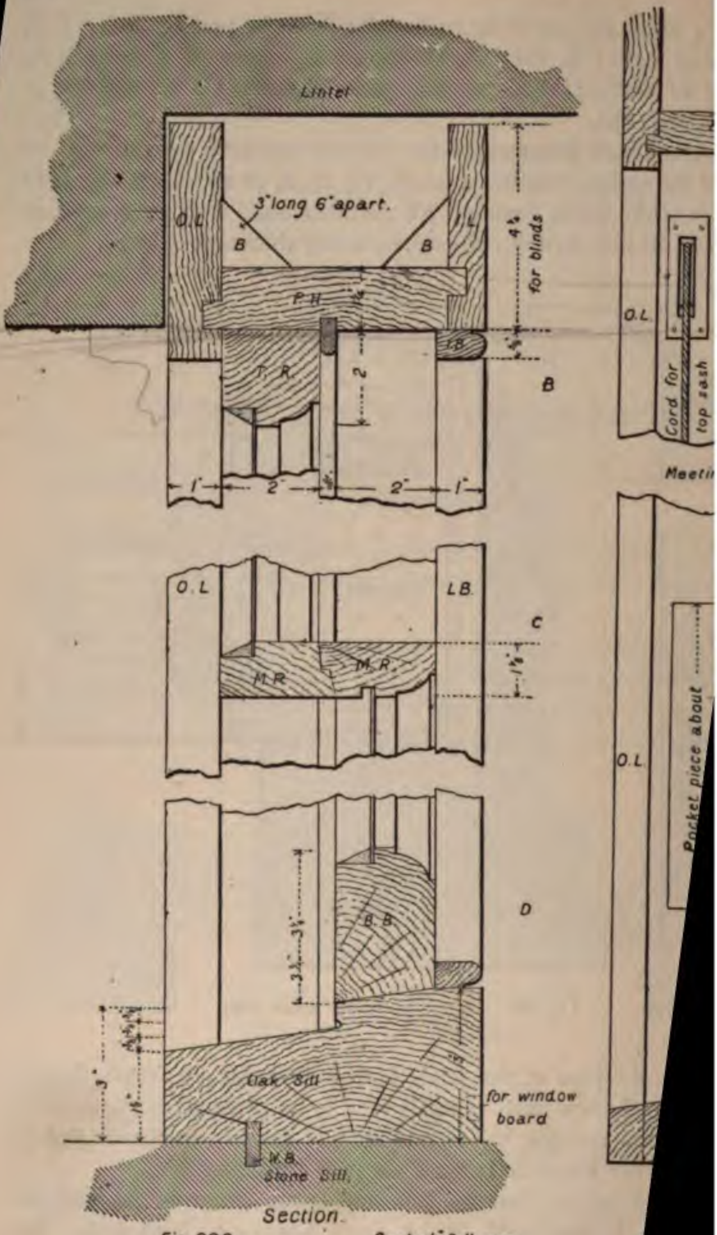


Fig. 698. Scale ¼" full size.

parting lath, P L, inside the boxing—the same side as the the parting bead outside. This parting bead should be to provide against undue swelling and sticking of the sash

Fig. 699 is an elevation of the pulley style, without the sashes in; and g. 700 a section, showing the working details of the axle pulleys, weights, rds, and pocket pieces, the latter of which are for putting in and getting

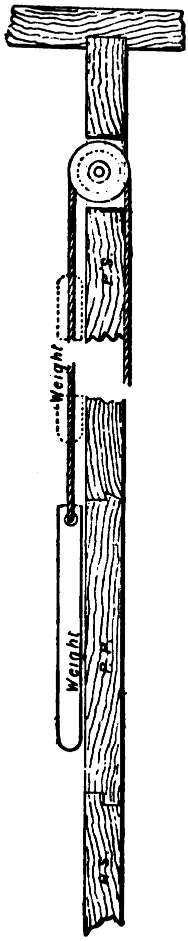
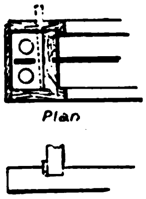


Fig. 700.
2" Scale.



Plan

Elevation.
Fig 701.

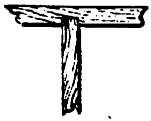


Fig. 702.

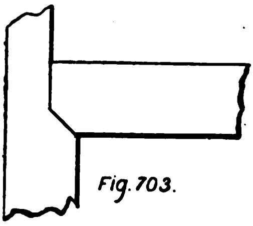


Fig. 703.

the weights, when hanging or regulating the sashes. One pulley is shown on each pulley style when the sash is 'single-hung.'

The pulley styles are housed and wedged into the oak sills, as shows ig. 701, and housed into the head which runs across at the top fig. 702.)

The linings are united at the top angles, as fig. 703; and the sill is notched out for them at the bottom, as fig. 704.

The meeting rails are always about ¼ inch thicker than the styles, or thickness of the sash, to fill up the space of the parting bead, which creates a space where the top and bottom sashes meet, as shown in fig. 705.

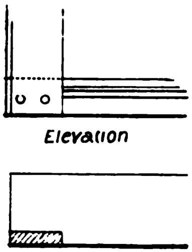


Fig. 704

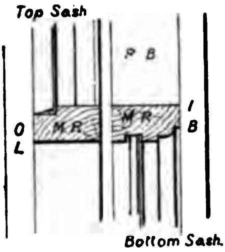


Fig. 705 2" Scale.

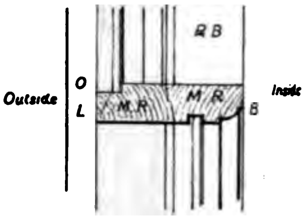


Fig. 706 2" Scale

Fig. 706 shows the space filled up properly by the meeting of the sashes, which should lock as shown, the top sash always being outside on account of the ledge which it would create at the meeting with the bottom sash if it were inside, as fig. 707.

Sometimes the oak sills are double-sunk, as shown in fig. 708, and the top or inside bead, I B, is made deeper, so that ventilation can be let into the room without creating a draught, by raising the bottom sash a little, so that it does not get above the top or inside bead, while the air gets in between the meeting rails of the sashes not properly locked, as fig. 709.

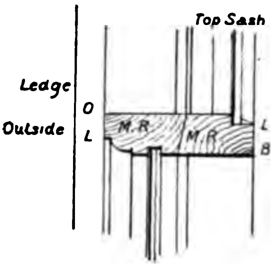


Fig 707 2" Scale.

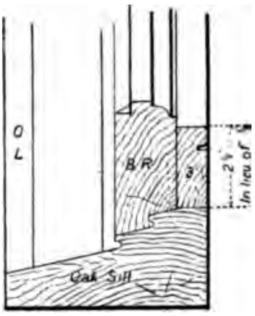


Fig. 708.

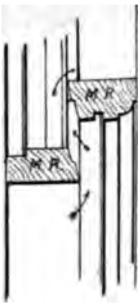


Fig. 709

To prevent the wet driving or sucking up the sills they and the top or inside bead, I B, are made to either of the sections on fig. 710.

The cord is connected to the sash style, as fig. 711, which is a view of the side of the sash style running up the pulley style; a space for the cord being made in the thickness of the style, as the plan shows, with an enlarged place for the knot, as on elevation.

The outside linings of the frames are often moulded on the edge in better work, as fig. 712.

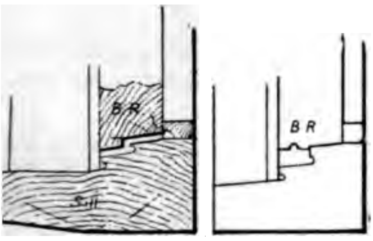


Fig. 710.

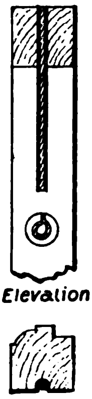


Fig. 711.

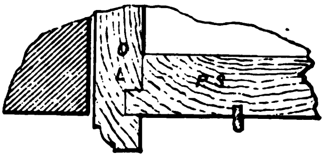


Fig 712

The sashes themselves are moulded to a variety of designs; fig. 713 being chamfered; fig. 714, ovolo-moulded; fig. 715, lamb's-tongue moulded; fig. 716, astragal and hollow-moulded; fig. 717, moulded.

All rebates for the glass in the sashes should be no less than ⅜ inch deep, and about ¾ inch wide.

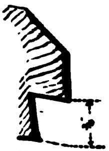


Fig. 713.

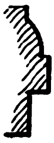


Fig. 714.

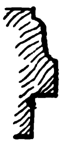


Fig. 715.

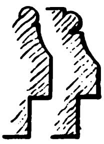


Fig 716.

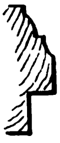


Fig. 717.

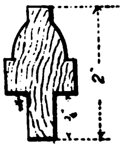


Fig. 718.

Sash bars are of width varying from ¾ inch to 1½ inch, by the thickness of the sash; but the thinner they are the better, as they do not block up so much light. They are moulded on each side to the moulding of the sash itself, an ovolo-moulded sash being as fig. 718; and they are connected together, as fig. 719, by a scribing and mortise and tenon; T being the tenon, M the mortise, and S*c* the scribing.

Those in the direction of the jars or blows are made the "through rs, with the mortises. The other joints between styles and rails ar cribed, mortised and tenoned together, and wedged up.

When sashes are not hung they are said to be *fixed* sashes.

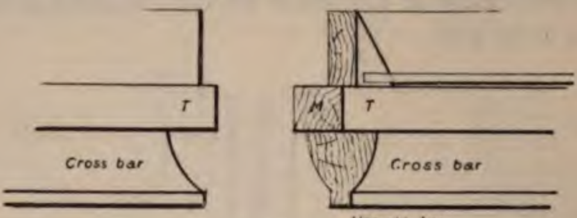


Fig 719

Venetian sashes are 3-light windows, the centre light being larger than the sidelights, as fig. 720; the boxed mullion between being as fig. 721,

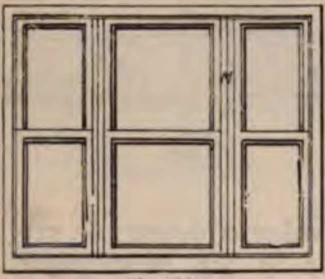


Fig. 720.

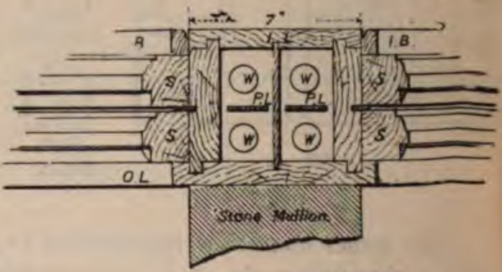


Fig. 721. 1½" Scale

when all sashes are hung; and fig. 722 illustrates the treatment when this is not the case; the mullions taking up far less room; and the weights of

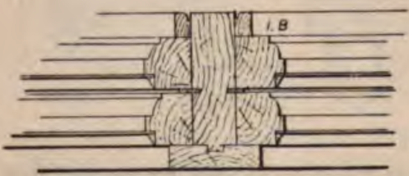


Fig. 722.

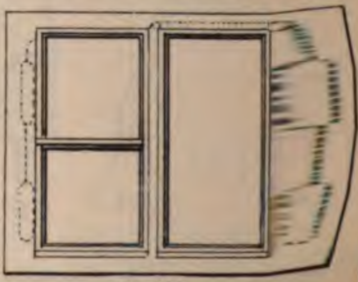


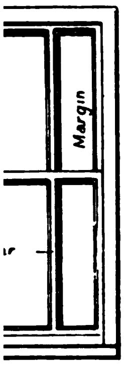
Fig. 723.

the centre sash (the only one hung) are enclosed in the jambs, the cords being worked by pulleys over the sidelights, as fig. 723 will explain, the lights being shown to illustrate the difference of working as compared

al sashes have a narrow margin formed by a sash bar up or
lights, the space between the bar and the style being the
fig. 724.

and *double-hung* sashes have been explained in the general
.

r-headed sashes have the underside of their top rails and the



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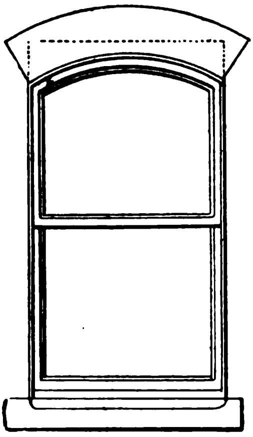
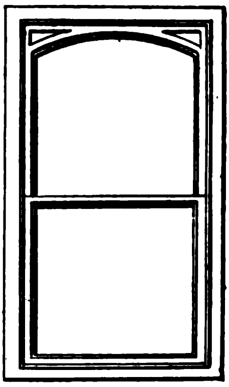


Outside.
Fig. 725.



Inside
Fig. 726.

e outside linings cut to the outline of the arch, while the inside
are and flat (figs. 725 and 726).

r-headed sash frames have their boxings, as well as their sashes,
ularly inside and outside. But the only difference noticeable in

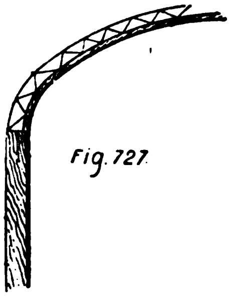


Fig. 727.

, that the pulleys must be placed below the springing line. The
e same, and the elevation of course different, showing exactly what
. The pulley style is cut to a thin veneer, and blocked out, as
two bending over and meeting at the crown, where they are joined.
are secured by means of sash fasteners, consisting of a lever
screwed to the upper side of the meeting rail of the top sash,

which turns under a catch, screwed by a plate to the upper meeting rail of the bottom sash, as fig. 728.

When large heavy sashes are used they are lifted up, opened, by projecting or flush lifts fixed to the bottom rail o sash, and the top sash is pulled down by a ring fastened to its

Solid Frames are made of solid heads, sills, and jamb

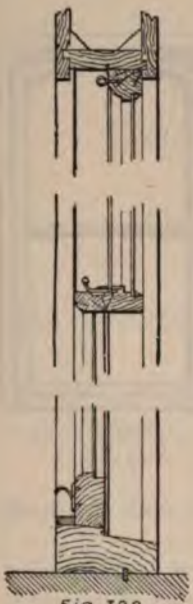
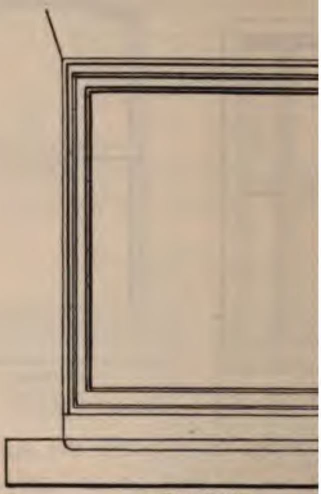
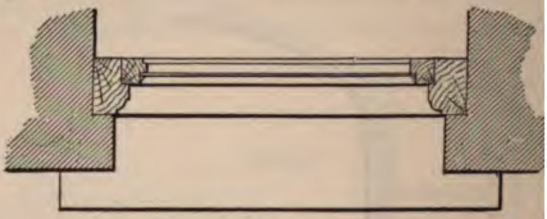


Fig 728



Elevation
Fig 729.



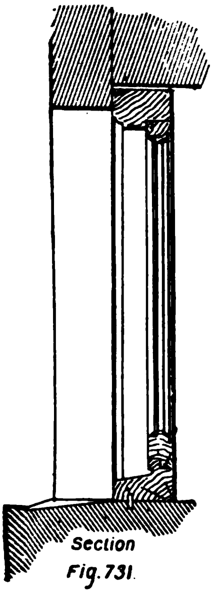
Plan.
Fig. 730.

door-frames, and filled in with casements exactly the same a hung by "butts" to the sides of the solid framing.

There is very little difference to be noted on the exter as compared with that of a sash or cased frame, except t no meeting rails to be seen; the real difference being in t them, as shown by plans, sections, and of course the details.

Figs. 729, 730, and 731 represent the elevation, plan, a

-framed, single-light window, with a casement hung to a jamb inwards. It will be noticed that the brick jambs need not be ; 2 inches is quite sufficient as compared with 4½ inches for a ame ; and, moreover, a solid frame does not require so much depth for its thickness, 4½ inches again being ample, whereas some or cased frames require as much as 6½ inches; but this varies ng to the thickness of the sashes, linings, etc.



Section Fig. 731.

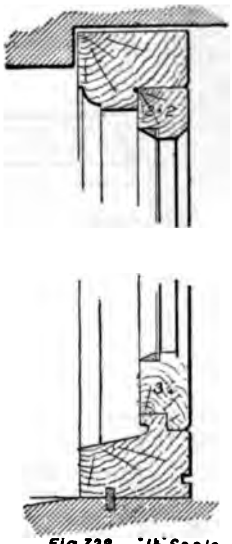


Fig. 733. 1½ Scale.

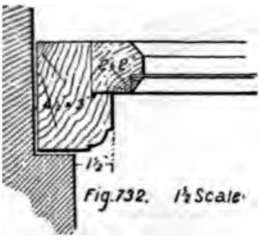


Fig. 732. 1½ Scale.

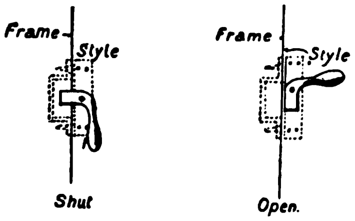


Fig. 734.

ig. 732 is an enlargement of the plan of a jamb or section of the both being alike; and fig. 733 is a section of the sill of chamfered nents and frames to open inwards.

he casements are hung to the jamb by a pair of 2½ or 3-inch butts, ecured by a *casement fastener*, the principle of all the very numerous ent kinds being a handle with a pin, which turns on a brass plate ed to the casement, and enters into a mortise or staple on a plate ed to the solid frame (fig. 734).

Fig. 735 represents plan and section of head, and fig. 736 a section of the sill, of a moulded casement to open outwards.

These are hung and fastened in the same manner as the last-named, and the opening arrangement is regulated by means of a stay with a movable joint fixed to the bottom rail of the casement. The arm is pierced with a suitable number of holes, which fit on to a pin, screwed by a plate

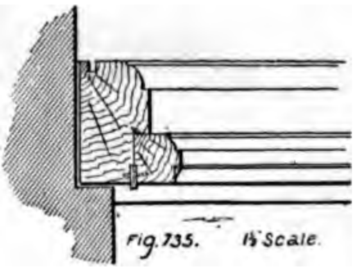


Fig. 735. 1½" Scale.

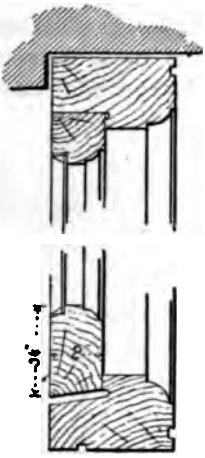


Fig. 736 1½" Scale.

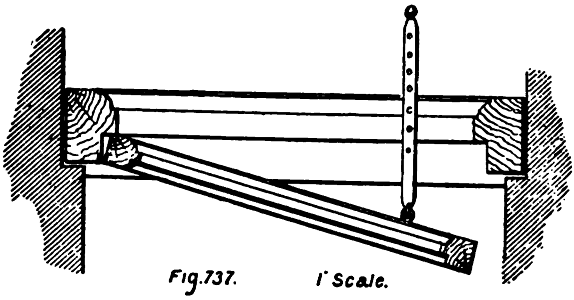


Fig. 737. 1" Scale.

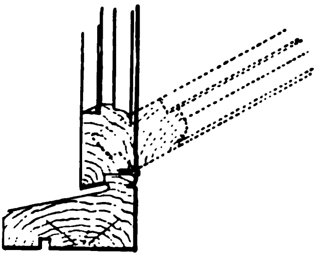


Fig 738 1½" Scale.

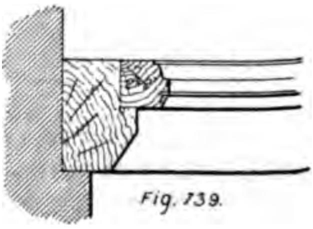


Fig. 739.

sill, whereby the opening may be regulated and the casement fixed position required (fig. 737).

pper casements are similar to hopper fanlights and fall inwards, being

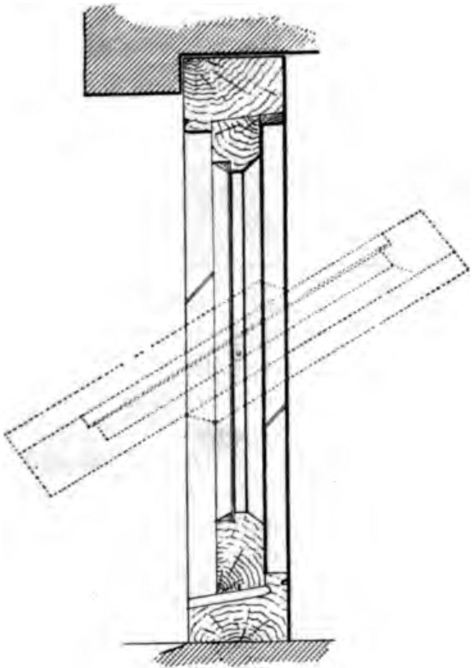


Fig. 740

ing to the sill, as fig. 738, fig. 739 being a section of jamb and head with mb's-tongue moulded casements.

They are secured by the spring fastenings illustrated in the last chapter.

Pivoted casements, or those hung on centres, are explained by fig. 740,

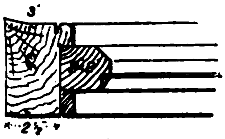


Fig. 741.

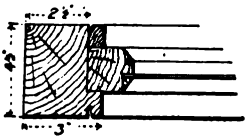


Fig. 742.

figs. 741 and 742 being sections of the jamb above and below the pivots. If any further explanation is required, the student must refer to the same kind of thing in fanlights, where their principle is described in detail.

Sliding casements, as the name implies, are those which are made in two sections, the one to slide past the other. Fig. 743 is a plan of a frame, filled in with two sliding casements, of which L L are locking styles, each being rebated out to fit the other; and figs. 744 and 745 give sections of the sill and head.

It will be gathered from the drawings that these last casements have the advantages of sashes, in that they neither open inwards nor outwards, which may be said to be disadvantages in casements and solid frames, and, moreover, they are not so liable to let in the wind and wet as hanging casements; but, on the other hand, they require more space in thickness, and often cause trouble with narrow jambs.

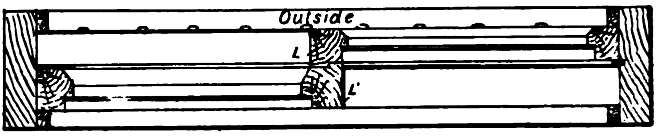


Fig. 743.

Sometimes the casements are kept in their place by iron studs, let into the sill, as fig. 746; and the writer thinks that to be the better way, as it is not so intricate and, consequently, not so liable to defects.

French casements are folding casements and windows, which answer the purpose of doors as well, being continued down to the floor-line. Fig. 747 is an elevation, and fig. 748 a section of one. The details of jambs, meeting styles, heads, and sills, are similar to those of ordinary folding casements; but these have to be thicker, 2¼ inches, and each casement is more like a sash-door with diminished or gunstock styles; and where the glass panel is very long, a low panel, like that of a door, is framed at the bottom, to lessen it, as fig. 747.

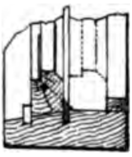


Fig. 744.

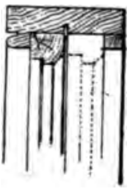


Fig. 745.

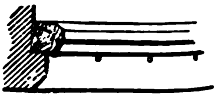


Fig. 746.

Hit and miss casements are those used for farm buildings, etc., as figs. 749 to 752, the top part being glazed between moulded bars, stumped into head and transom; and the lower part consisting of upright slats, with alternate spaces framed into transom and sill outside, with slatted

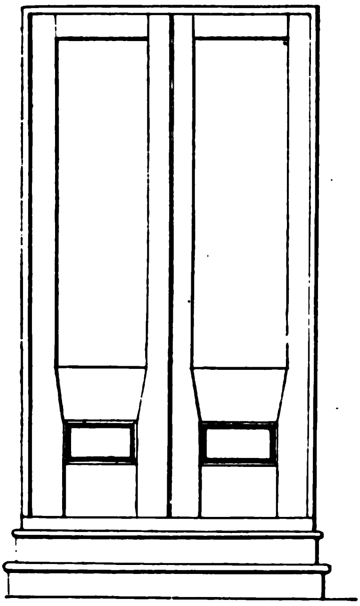


Fig 747 ⅛ Scale.

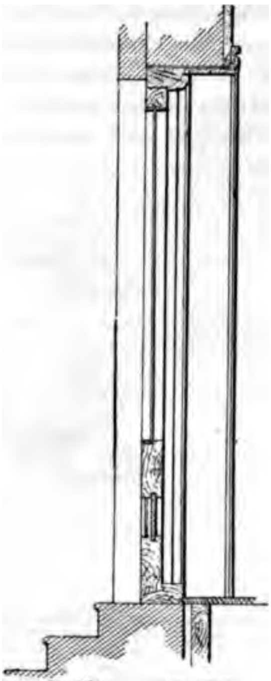


Fig 748 ⅛ Scale

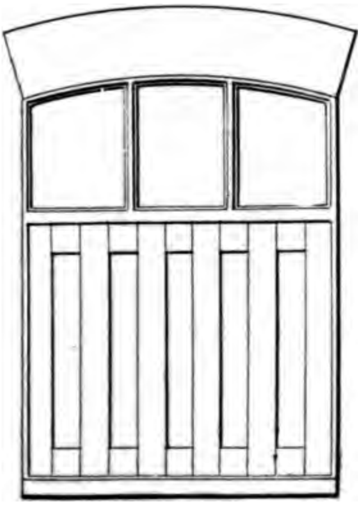


Fig. 749.

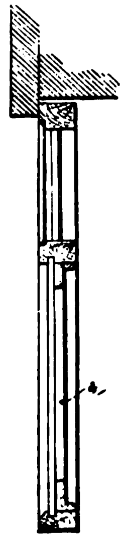


Fig 750

framing within, which, being moved aside two or three inches, either ope or closes the alternate spaces between the single slats outside. One pl shows the slatted frame moved aside, so that the holes are open, and t other plan shows them shut.

Two-light solid frames are those which have a solid mullion, which

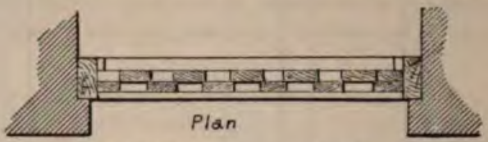


Fig 751. ½ Scale

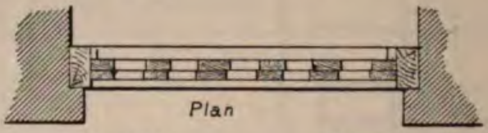


Fig 752 ½ Scale

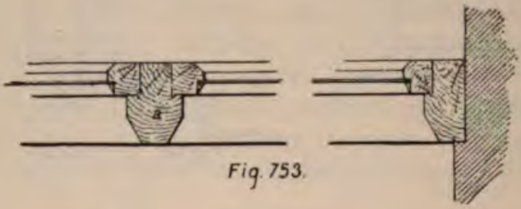


Fig. 753.

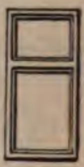


Fig. 754.

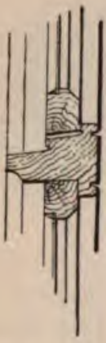


Fig 755

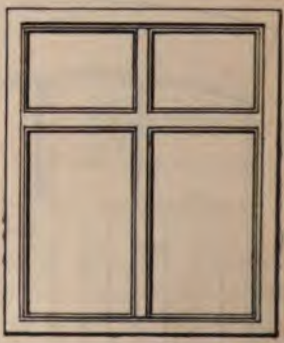


Fig. 756

treated like a double jamb, as at A, fig. 753; but they may also be ma two-light by a transom, one light above and one below it, as fig. 754; t transom being in section similar to fig. 755, which is for both casemen made to open outwards.

It will be understood that the section of the transom varies in eve case, where the top and bottom lights differ with regard to their opening and shutting. From the various illustrations given in these notes the student ought to be able to draw them to suit any requirements.

Four-light casements and frames are generally made by a mullion and transom, which divide the opening into four spaces, as fig. 756.

Sometimes the casements are *hung folding* in solid frame, in which cases the section of the meeting or locking styles is made as fig. 757; or it is occasionally treated as fig. 758.

It has been proved that it is a great advantage to make the rebates on the solid frames and the side of the hanging style of tne casements, as fig. 759—*i.e.*, on the splay; the contention being that the joint fits better and tighter, without any liability to knock the edges off the styles when the casement opens, as shown by the comparison of figs. 760 and 761. The outer edge of the style gets away quicker in the one case than in the other.

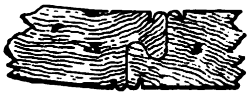

Hooked rebate

Fig 757

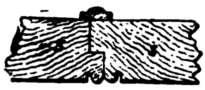


Fig 758.

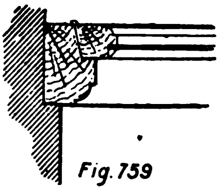


Fig. 759

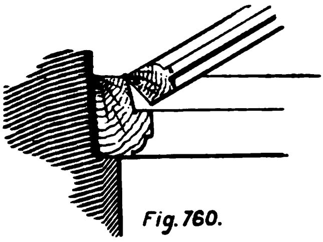


Fig. 760.

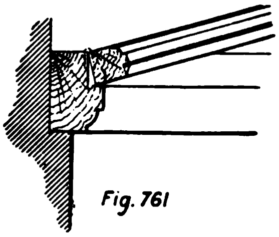


Fig. 761

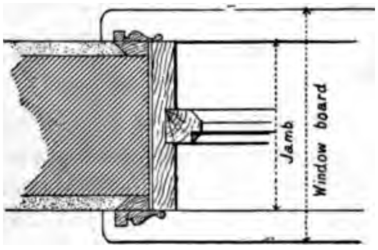


Fig. 762

Borrowed Lights, of which the object is to give light from one room to another which has no external walls, consist of a plain sash, rebated and fixed into a plain lining, of the thickness required by the walls. The lining goes all round the opening, as fig. 762, but a little wider at the bottom, to form a window-board, which takes the place of the architrave on the jambs and head.

Water bars, of iron or brass, of different sections, are often fixed to the bottom or end of casements, as fig. 763, which is only one of the many equally efficacious patented methods for keeping out driving rain.

Weather boards are another means of throwing the water off the bottom of casements. They are of wood, and similar in section to fig. 764, being tongued into the bottom rail, or housed.

Window Finishings.—The finishings to cased and solid frames being alike, the student must understand that the various framings, mouldings, etc., explained in this chapter equally apply to both kinds of windows, although each kind of work will be shown in connection with a cased frame.

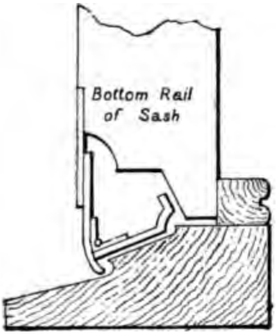


Fig. 763

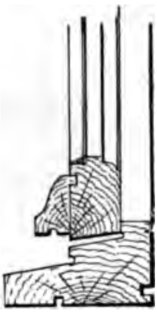


Fig. 764.

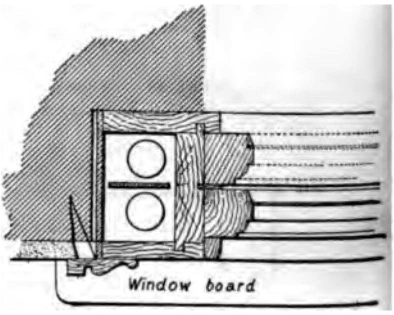


Fig. 765

In common work, where the back of the window frame finishes flush with the face of the plastering, the only finishings required are a window-board at sill line and an architrave up the jambs and across the head.

Fig. 765 represents a jamb, and fig. 766 the head and sill of a window, treated as above.

It will be noticed that the architrave is fixed to "plugs," grounds being seldom used to ordinary windows; and the window-board is grooved into the oak sill.

Window-boards have rounded nosings, as fig. 766; or they are moulded with a bed-mould underneath them, as fig. 767, in better work.

Architraves may be single or double, the single being as shown on figs. 765 and 766; and the *double-faced* (the proper term) are as fig. 768, consisting of two separate moulded members.

When the sash frame does not take up the whole depth of the jamb nings have to be employed to make a finish up to the face of the lastered wall, and the window-boards have to be widened, as figs. 769 nd 770.

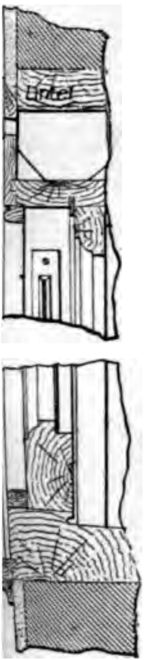


Fig. 766.

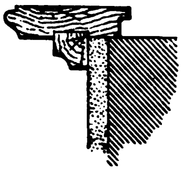


Fig. 767.

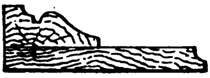


Fig. 768.

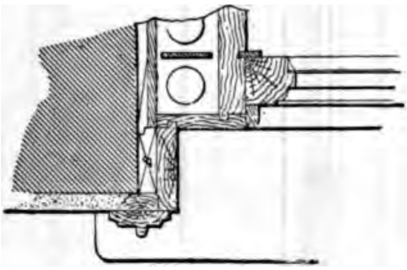


Fig. 769.

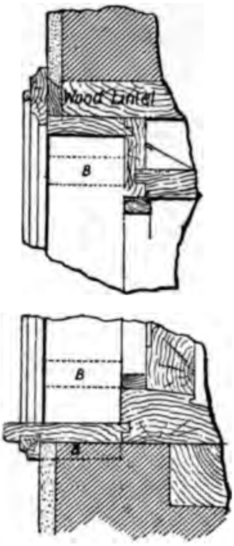


Fig. 770.

The window jamb linings are grooved into the inside linings of the frames, and fixed to backings, B, which are secured to plugs in the wall.

The window-board, being of increased width, also requires backing underneath, as shown.

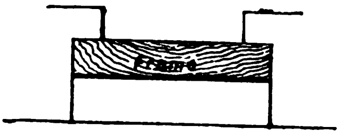
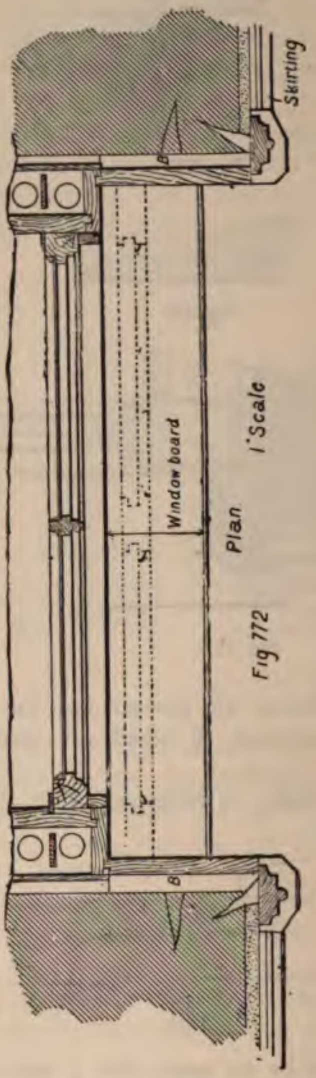


Fig. 771.

All backings should be no more than 3 feet apart.

Sometimes, in these wider walls, the brick or stonework is left out between the jambs, beyond the back of the frame, from the window ill to the floor line, as fig. 771, in which case the jamb linings of he windows last described are continued down to the floor, and called *elbow linings* below sill level; and this finishing of course dispense with the wide window-board, the narrow nosing (figs. 765 and 766 being again brought into requisition; and beneath it, instead of plaster



Plan

Fig 772

we have wood panelling, called *window backs*, from beneath the windo board to the floor-line; the skirting, as around the room, covering the le or styles, which run down as explained in fig. 774 (for dadoes).

Fig. 772 represents a plan, and fig. 774 a section of a window treated and finished off in this way.

From the front elevation, fig. 773, the window back will be seen

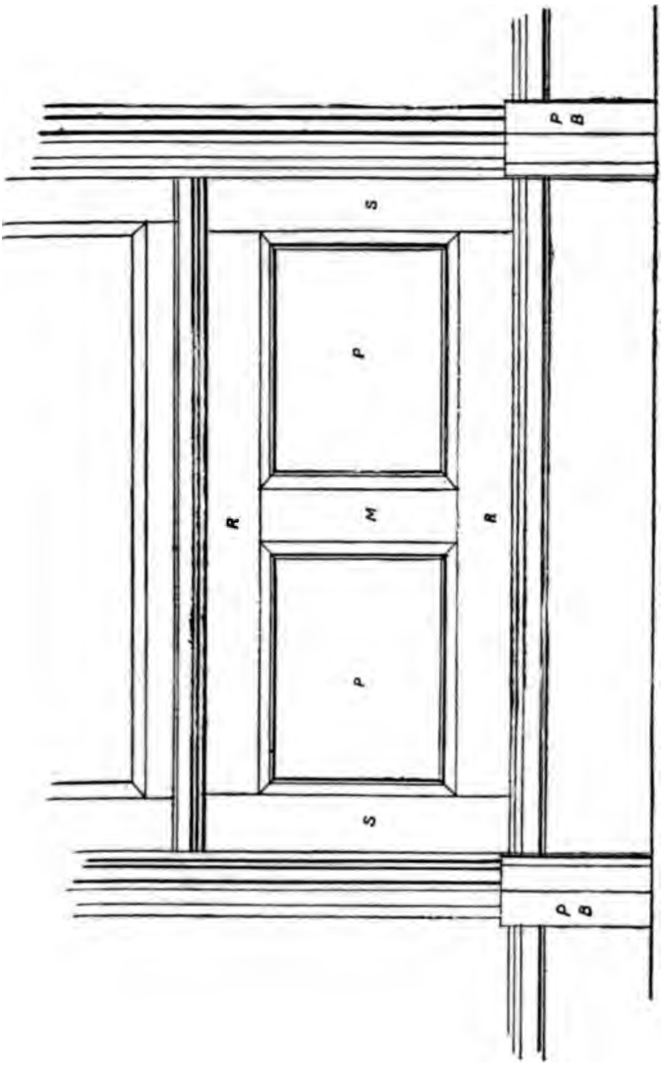
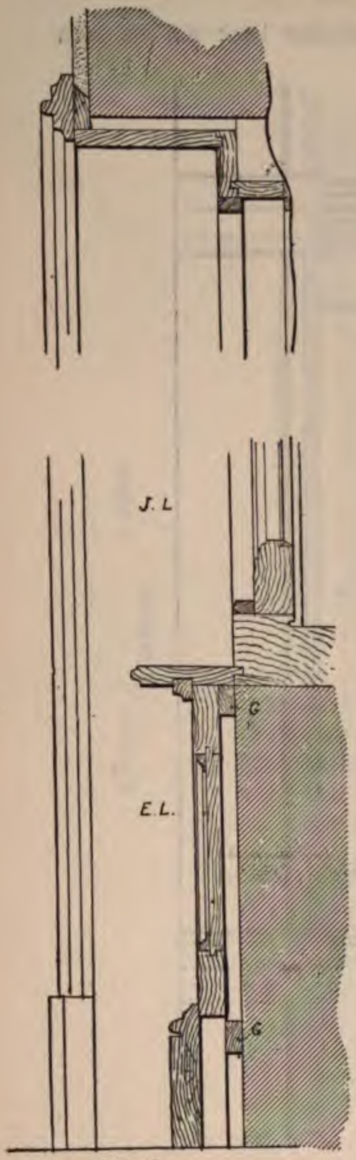


Fig. 773. Elevation 1" Scale.

to consist of a panelled framing about 1½ inch thick, flush at the back and fixed to grounds, as G on section, fig. 774. The front of the panelled framing may be plain, chamfered, or moulded to any design, and the usual method is to show the window backs by dotted lines on the plans, as fig. 772. The jamb and elbow linings combined are fix



Section.

Fig. 774 1' Scale

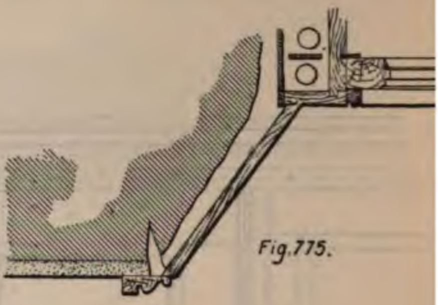
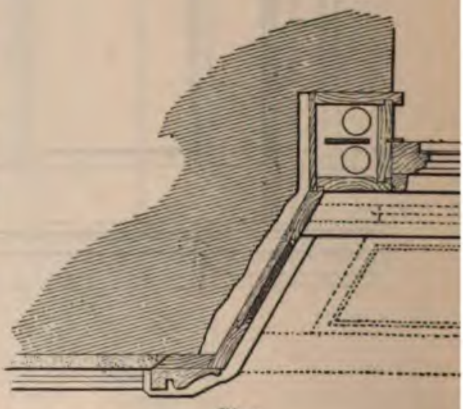


Fig. 775.



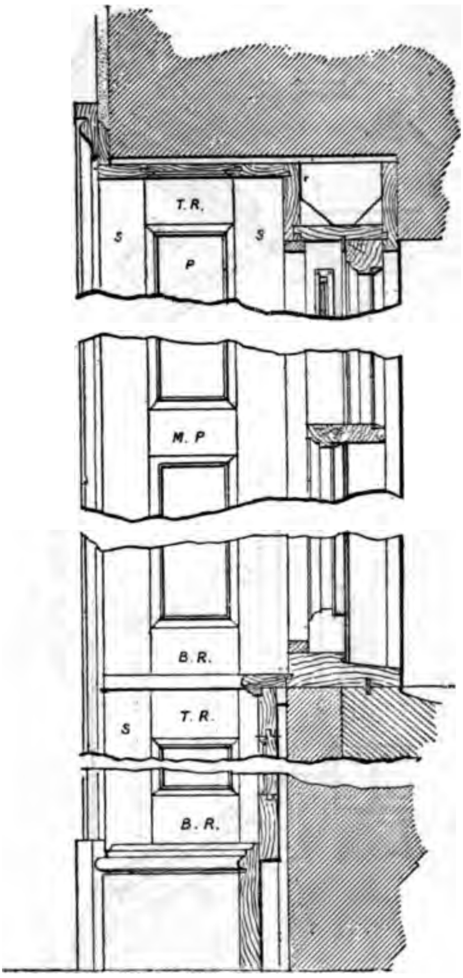
Plan

Fig. 776. 1' Scale.

on the splay, as fig. 775, when they are called *splayed lining*, the
of course remaining *flat*.

inings are tongued at their top angles, just as door linings or gs, to join the horizontal to the vertical portions.

'linth blocks or bases, P B (fig. 773), are often put at the bottom

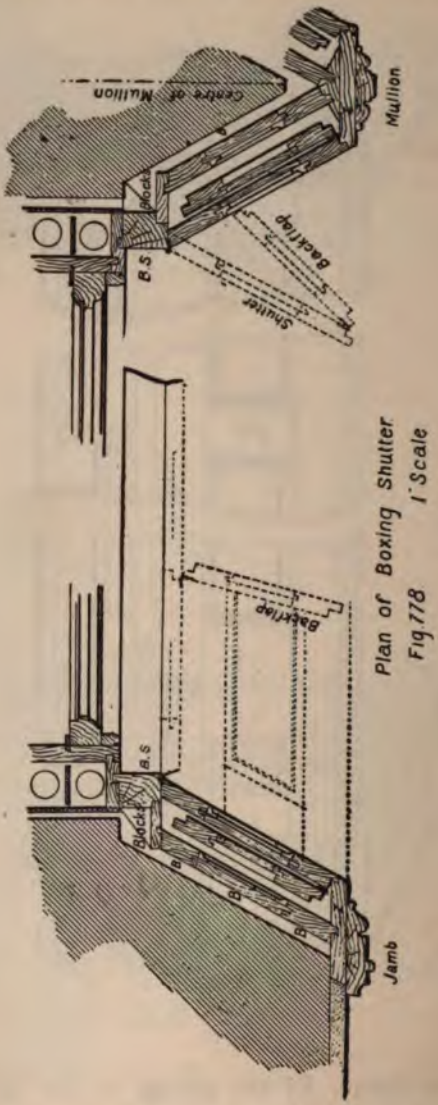


Section.
Fig 777.

chitraves, as shown, for the skirting to run up against, as well r appearance.

inings, in the best work, are often panelled, whether square or on , the soffits also being treated in the same manner. Figs. 776 777 will fully explain all matters in connection therewith; though

it may be well to remark that that part of the lining called the *el*
should be made to range with the panels of the window backs,
the window nosing returned round it in the shape of a flush-



Plan of Boxing Shutter
Fig. 778 1" Scale

(fig. 777), because the architrave would not allow of the board
being returned.

In designing window finishings the blinds should always be n mind, and spaces left on each side the window and above the head or them; and it will be noticed that provision has been made for hem in every case hereinafter illustrated and explained.

Shutters, as applied to the internal finishings of a house, are of wo kinds—boxing shutters, and lifting or sliding shutters, their object eing to give greater security and warmth at night.

Boxing shutters are also called *folding* shutters, because they fold back, nto one or two leaves, into the "boxings" which are made for them where he jamb linings are usually fixed.

The first thing to be done, according to fig. 778, is to leave a space or the "blinds" all the way round the window by "blocking-out" (as hown by B S on all the drawings), and to this member the shutters re hung. To the left of the blind fillet we get a plain side of the oxing, blocked out from the wall to the face of the blind space or llet; and into this is tongued the back lining of the boxing, which is enerally panelled, moulded, and fixed to backings like a jamb lining, ecause it is visible when the shutters are unfolded to cover the indows. The other end of this back lining is tongued into a wide oulded ground, which is securely plugged to the brickwork, and in ddition to its own work forms a rebate for the front shutter and part f the double-faced architrave (as Z), on which the other member of he architrave is fixed.

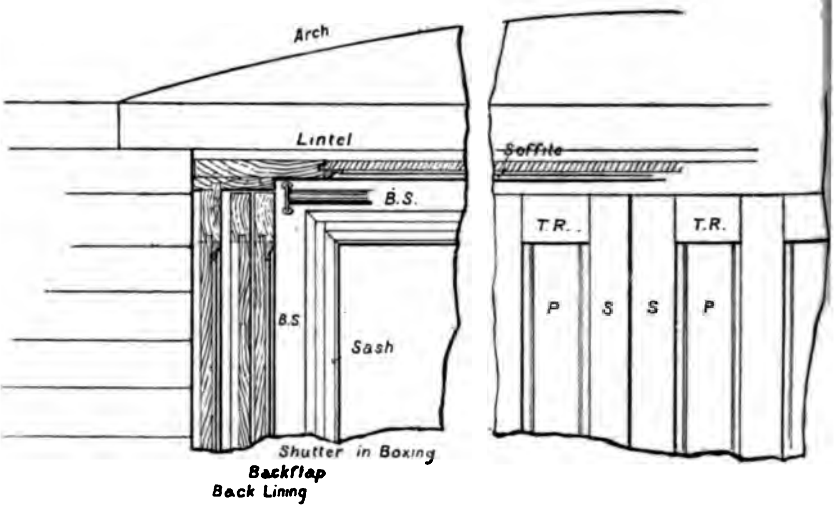
Having completed the boxing according to plan, the shutters (which re usually 1¼ or 1⅛ of an inch thick) only have to be put in, and the front hutter is panelled, moulded on the face exposed in the daytime, to the ame design as the window backs, soffits, elbow linings, and other work n connection, and the hinder side of it is generally made "bead butt," as s also the same part of the back flap or other shutters, which are exposed y night when the shutters are unfolded. The other part of the back ap is left square-framed.

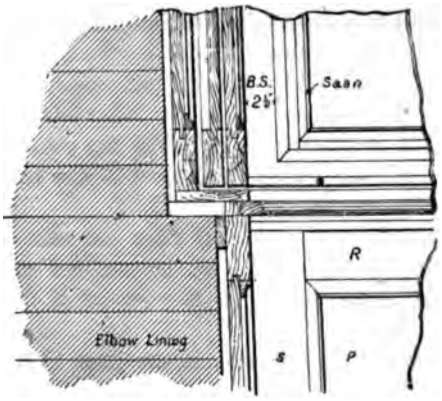
The edges of the styles of all shutters and back flaps are rebated ut alternately, so that when they are unfolded they fit together and orm one surface, with no spaces at the joints, as they would if they ere square-jointed.

The elevation of the shutters is exactly the same as the jamb linings f a window, and the soffits, window backs, and elbow linings are made nd used in the ordinary way; in fact, a window with shutters is not omplete without them.

It is unnecessary to explain and illustrate these matters again. The tudent must look back to the part of this chapter concerning them if he still requires any information.

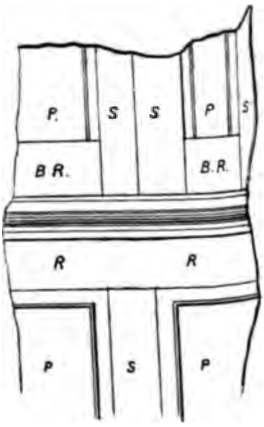
It may be as well, however, to give a section through the head, op, and bottom of the boxing, and also to show the sill and the mode of dealing with the bottom of the shutters at window-board level, to allow of the space for blinds when the shutters are in use (*vide* figs. 779, 780, and 781).





Part Sectional Elevation

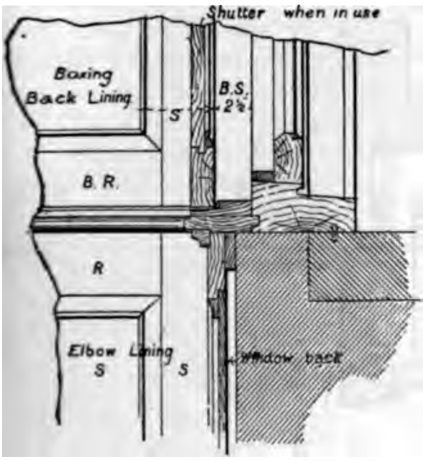
Fig.779 1" Scale



Part Elevation
Showing Shutters Closed.

Fig.780 1" Scale.

At the top, as fig. 779, the styles of the soffit run through, and an irregular piece of wood about ½ an inch thick, beaded on the front edges, is nailed underneath them to lower the top of the shutters, so that when they are unfolded their tops do not touch the underside of the soffit. The bottom is treated in a similar way, to prevent the shutters from scratching the window-board.



Part Sectional Elevation
Showing Elbow Lining etc
Fig. 781. 1" Scale

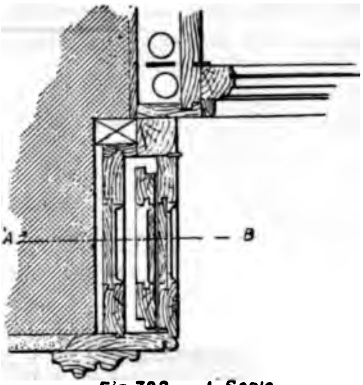


Fig. 782. 1" Scale.

The section of the sill (fig. 781) will explain how the shutter bottoms are treated there, to allow of stopping in front for blind space. In very thick walls the shutters are often made square—*i.e.*, at right angles to the windows in lieu of *on the splay*, as fig. 778, which is the common way in ordinary walls. Fig. 782 gives a plan of such method, and it is needless to give any other details, as they are similar to those already given.

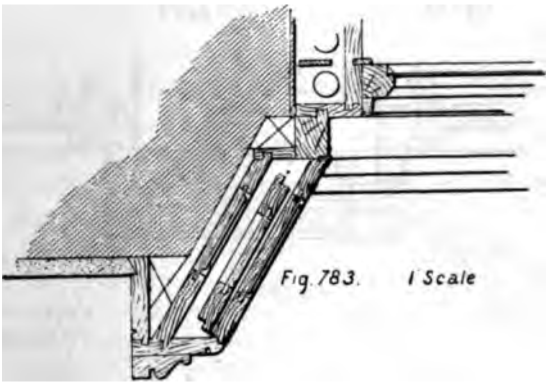


Fig. 783. 1" Scale

In thinner walls, where there is no room for shutters of ordinary and reasonable widths, the boxings have to be blocked out beyond the face of the plastered walls, as fig. 783 for splayed shutters, and fig. 784 for square shutters.

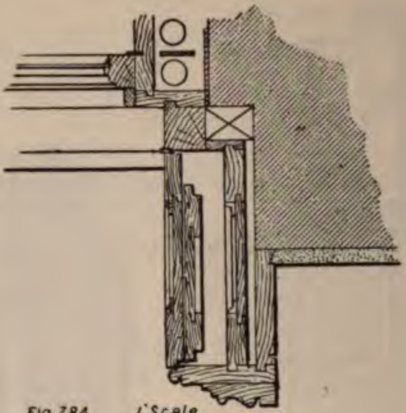


Fig 784 1" Scale.

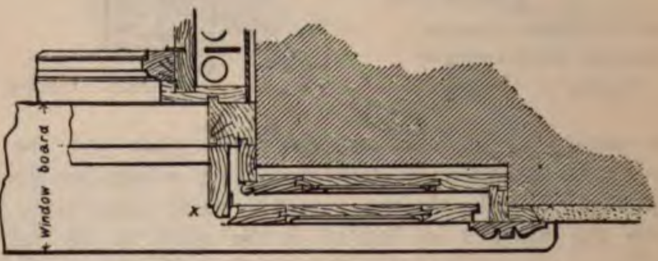


Fig 785. 1" Scale

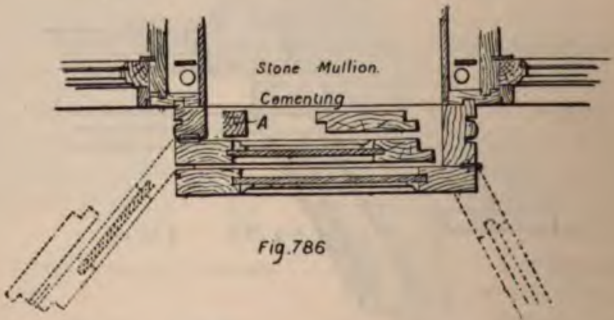


Fig.786

Another method, as fig. 785, is to throw a wide flap back on the face of the wall, the joint between the small and large parts, at **X**, being called a *rule* joint, on account of its similarity to the joint of a 2-foot rule; and they are treated as mullions, as fig. 786, where they do not want projecting boxings (as in figs. 778, 783, and 784). It will be seen on fig. 786 tha the mullion must be wide, so that the shutter and back flap, which are hun to the blind space, can be got into a small boxing blocked out on the right hand side by a moulded upright to which the front boxing flap is hung and when the shutters are out and in use a small blocking, A, hinged t the left blind space (smaller than the right), is brought out to receive th back of the boxing flap, and make a complete ornamental boxed mullion as if the shutters were not in use and formed it.

Folding or *boxing* shutters are sometimes made in two heights, th joint being at the meeting rail level of the sashes; and where they are i one height a flush bead is often worked on them at that level, as X, on fig. 787, which may either represent a flush bead or a beaded joint.

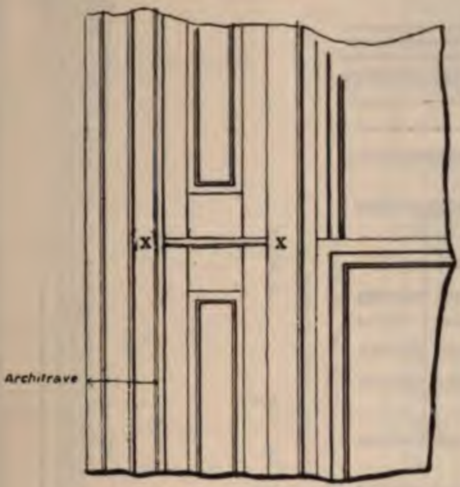
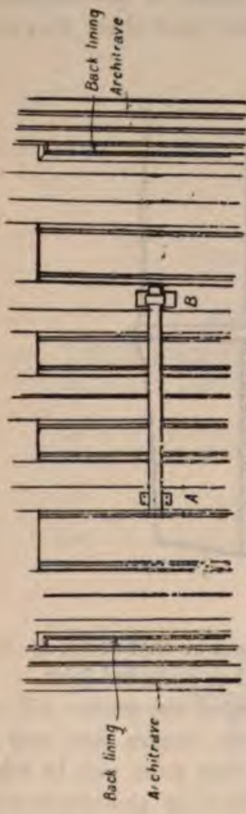


Fig. 787 1' Scale

From the preceding illustrations and explanation the student will have noticed that the back flap is narrower than the shutter, and only one back flap has been shown on this illustration; but more may be added, according to the size of the window, to be covered by shutters from two boxings, one set on each jamb. Still, it is always better, where possible, to have wider shutters and back flaps, and less of them in number, as the more there are the more likely they are to get out of order. At best they are often very awkward and troublesome.

In setting out this kind of shutter great care must be taken that the rebates are in pairs, one to fit the other—not forgetting the meeting styles of the sets from each jamb. It is always of advantage to leave as much space as possible between the shutter and back flaps, when in the boxing, to make room for the shutter bar, etc., which is secured to the back of the shutter.

Shutters are hung by small special butts, called *back flaps*, fixed about 3 feet apart up the styles, the complete set of shutters (when unfolded) being held together in position by the shutter bar, which stretches from behind the back of the back flap of each jamb, as fig. 788, and is secured to one shutter by a loose joint, to fall down, when not required, at A; and let into the other, at B, when in use.



Part Elevation of Shutters Showing Shutter Bar

Fig 788. Fig ½ Scale

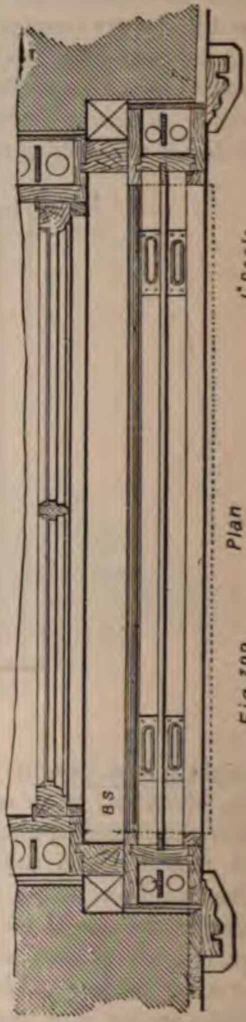
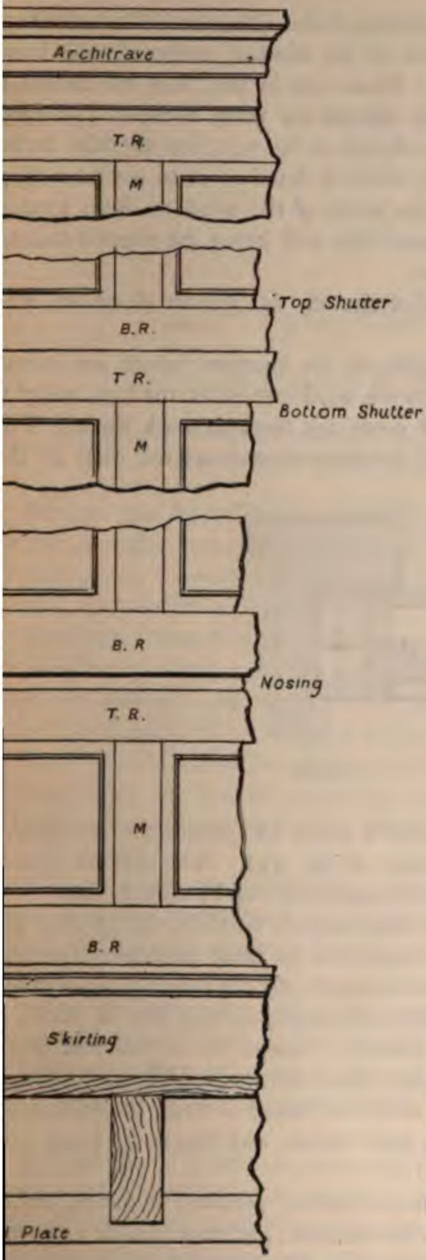
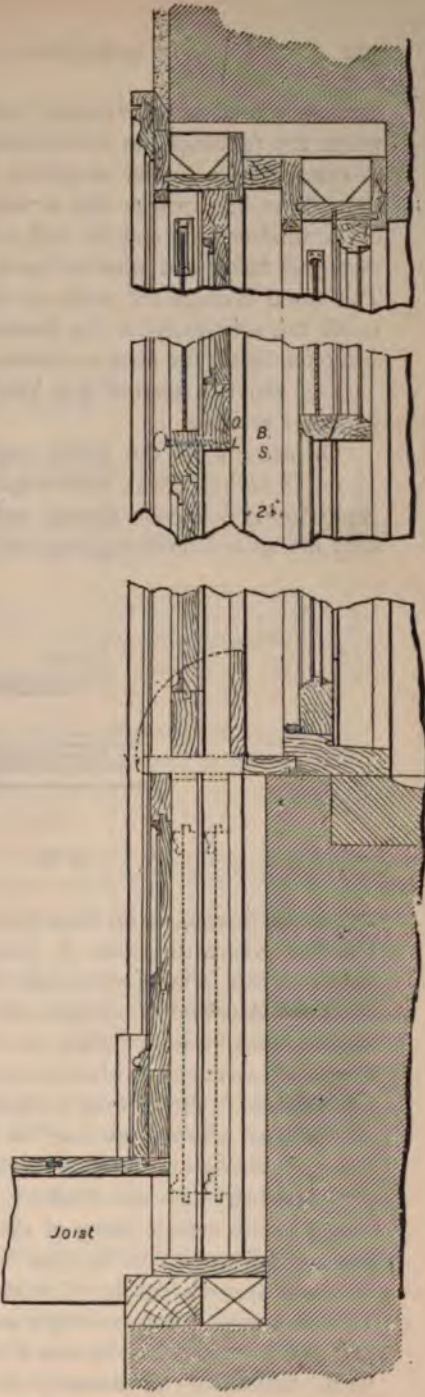


Fig. 789. Plan 1" Scale.

The other kind of shutters, for internal windows, though not so



art Elevation.
0, 1" Scale



Section,
Fig. 791. 1" Scale.

commonly used as the "boxing" shutters, is the *lifting* or *sliding* shutters, which are framings the whole width of the window, enclosed and hung in cased frames similar to sashes. When not in use, they are made to slide down the casings into a well, formed for them between the back of the window back and the wall, as shown on fig. 791, the toprails being then just below the window-board, which is fitted so as to act as a flap. The cased boxings are made up the jambs of the windows from underneath the soffit-lining to the bottom of the well below the window-board, and often below the floor, as shown.

Fig. 789 is a plan of this kind of shutter, fig. 790 an elevation, and fig. 791 a section.

On account of the heavy weights of the shutters (which are about $1\frac{1}{8}$ or $1\frac{1}{4}$ inches thick), lead weights are used instead of the iron weights generally used in sash frames, and cords are fixed to work them. The only fittings and fastenings required for these shutters are the rings in the top of the toprails, to lift them up, and a screw to connect the two leaves together, where they meet in position, as fig. 791. The window-board, used as a flap, is hung with small butts, and lifted up by a flush ring.

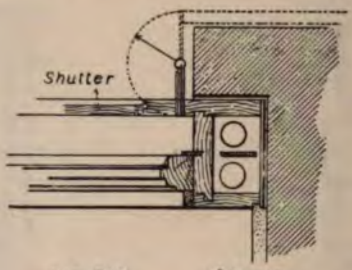


Fig. 792 1" Scale

Sometimes internal shutters are made to slide laterally, though they are seldom met with now. They are worked on the same principle as sliding doors and casements, to which the student must refer, the only difference being the lightness of the framing for shutters as compared with that for doors.

External shutters, whether for houses or shops, are now almost obsolete; but it may be as well to say that house shutters are folding framings, the same height as the windows, each fold being secured by *parliament* hinges to the outside lining of the sash frames, and thrown by them outside the brick reveal, as fig. 792.

Shop shutters consist of numerous narrow panelled framings, about 15 inches wide, the same height as the window; and they can be removed and put in position one by one at pleasure. They are secured by mortises in the bottom of the shutters, which go on to small dowels fixed on the window sill.

CHAPTER XIX.

WOODEN STAIRS.

Stairs and Staircases—Definition of Terms and Rules—Kinds of Stairs—Construction of Stairs and Details—Handrails.

Stairs and Staircases.—Stairs are the means by which ascent or descent is made from one level (or floor) to another. They can be made of stone, iron, concrete, or wood; but it is only intended to deal with wooden stairs in this chapter.

The stairs themselves are built up of a continuous range of light boards, grooved and tongued together, and arranged in horizontal steps rising one above the other in a raking line drawn from the bottom, or starting-point, to the top or place where it is required to land.

The ends of these boards or steps are connected to stouter boards, pitching from the bottom to the top to the raking line just alluded to; and they are often supported in the middle, as will be explained more fully hereinafter.

This structure of boards, etc., called stairs, connecting the different floors together, is enclosed in a *staircase*, which is either a specially built chamber, or a space or part of a larger apartment set aside for the purpose.

When the latter is the only provision made for containing the stairs, the floors and ceilings have to be trimmed, as fig. 793, in order to provide headway, and allow of communication between the stairs and the higher floor levels, with which the stairs themselves are the means of communication.

It is needless to say that there are numerous kinds of wooden stairs, differing from each other in principle and in form, but alike in general detail, although the mouldings and mode of treatment may differ a little However, before entering into these details, or going into an explanation of the different kinds, it will be as well to acquaint the student with the meaning of the different terms and rules applied to stairs in general.

Definition of Terms with Rules.—The *tread* is the flat horizontal surface of the step on which the foot is placed (distinguished by T on the illustration, fig. 794).

The *riser* is the vertical face of the step, or the upright, R, which connects the back of the lower tread with the front of the upper one.

The *nosing* is the edge of the tread, which projects beyond the face of the riser; it is usually rounded, and sometimes, by means of a small hollow fillet planted underneath, it is made moulded (as shown in fig. 794).

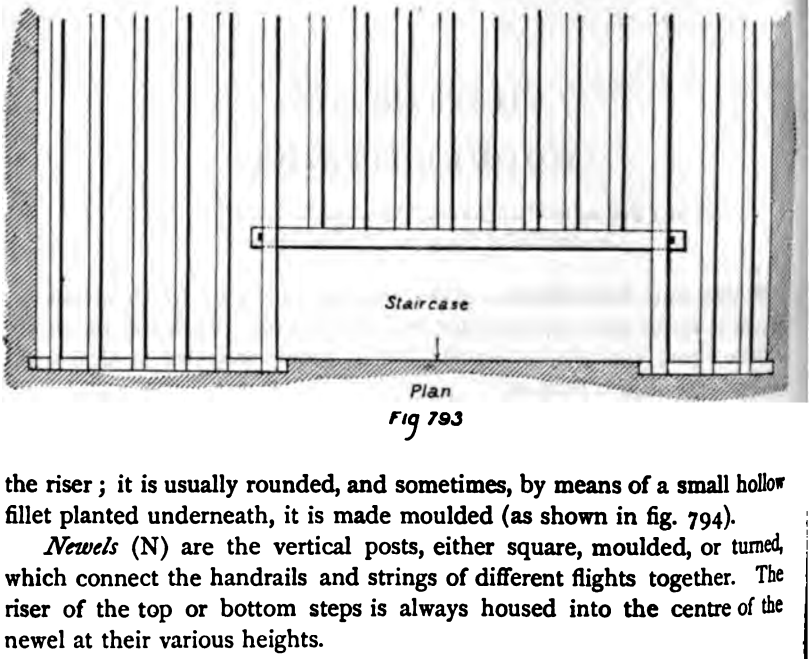


Fig 793

Newels (N) are the vertical posts, either square, moulded, or turned, which connect the handrails and strings of different flights together. The riser of the top or bottom steps is always housed into the centre of the newel at their various heights.

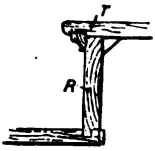
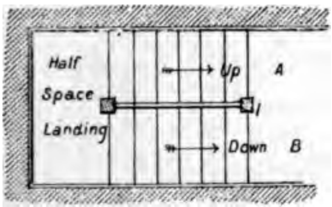


Fig 794

A stair generally starts with a newel where there is no wall to receive the ends of strings, handrails, etc., whether it be at the top or bottom, in each of which cases the newels are a convenience and an ornament.

The *strings* (S T) are the "walls" of the treads and risers of the stairs. Each step is housed into the strings at both its ends, the string running from newel to newel, or from floor to floor at the inclination of the stairs, and parallel to the line of nosings and the handrail.

The *handrail* (H) is a rounded or moulded rail, fixed above and parallel to the string along the walls, or from newel to newel, for the convenience and aid of persons using the stairs. It should be of such a section that it can be easily and comfortably grasped by the person ascending or descending the stairs.



Plan.
Fig 795.

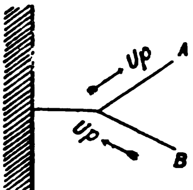


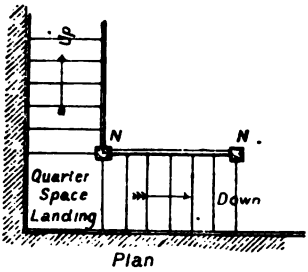
Fig. 796

Balusters (B) are the light upright posts or bars supporting the handrails between the newels, from the treads of the steps or string, and they can be square, moulded, or turned.

A *flight* is the series of continuous treads or risers, or steps, inclining from one landing to another, or connecting the different floors, if there are no landings.

A *landing* is the flat space or floor at the top of the stairs.

A *half-space landing* is a similar flat resting space between two flights, one of which returns upwards in a direction opposite to the other, which goes down, as figs. 795, 796. It is generally the width of the two flights.



Plan
Fig 797

A *quarter-space* is a landing half the size of the last-named, and extending across one flight only, the riser of the upward flight being at right angles to that of the downward one (fig. 797).

The *go* or *going* of a stair is the distance from riser to riser, and the "rise" is that from tread to tread.

The *going* of a "flight" is the distance from first to last riser, between landings, or between the bottom and top of the stair.

Fliers are the ordinary steps, rectangular in tread or plane; while *winders* are those of triangular form, which are employed in turning corners or curves.

Curtail steps are those generally at the bottom of a flight or stair, which have one circular end to tread and riser; and in the centre of the tread the newel is placed, as fig. 797A, the other end of the step being housed to the wall string in the ordinary way.

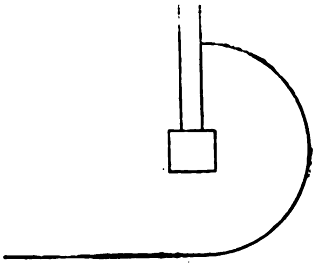


Fig.797.A

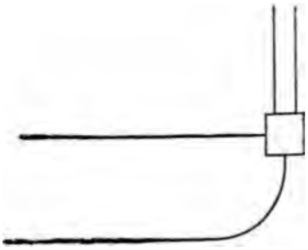
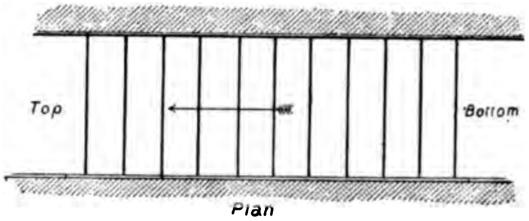


Fig.797.B

Bull-nosed steps are similar to the latter in form and use, but the end is only about a quarter of a circle in contrast to a "curtail" (*vide* fig. 797B).

It will be readily understood that the success of a stair depends on the convenience and ease with which it can be ascended or descended—*i.e.*, the *go* and *rise* of the step must be of suitable dimensions, and the flights short (*i.e.*, of no more than a dozen steps) between a landing, half or quarter space, on which to rest if necessary.



Plan

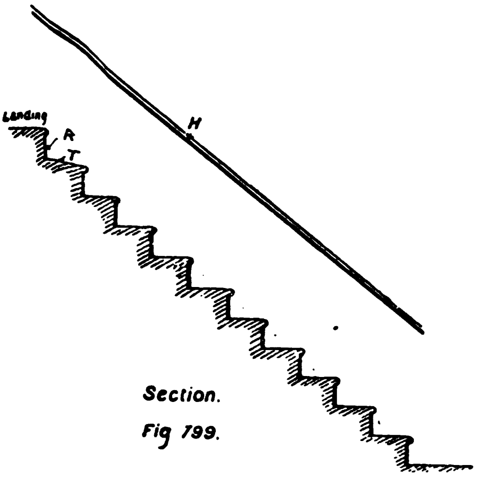
Fig 798

Various rules have been drawn up to regulate the width of the tread or "go," in proportion to the rise of the risers; but the writer considers that the following scale of proportion gives the most comfort and ease to the user of the ordinary stair, while it is also a simple one for the student to remember.

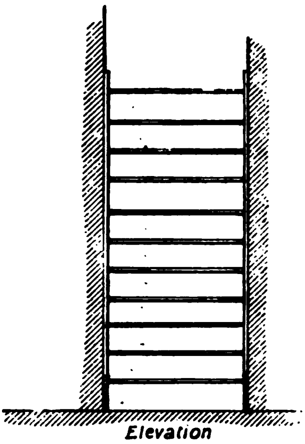
Take 9 inches wide for the tread, and 7 inches high for the rise of the riser, as the standard or basis; and accordingly as the tread increases or

es in *width* per *inch*, deduct or add ½ inch in rise respectively,
e :—

A 5-inch tread should have a 9-inch riser.
" 6 " " " " 8½ " "
" 7 " " " " 8 " "
" 8 " " " " 7½ " "
" 9 " " " " 7 " " (standard).
" 10 " " " " 6½ " "
" 11 " " " " 6 " "
" 12 " " " " 5½ " "
" 13 " " " " 5 " "
" 14 " " " " 4½ " "
" 15 " " " " 4 " "



Section.
Fig 799.



Elevation
Fig.800.

Another rule is that the "product" of width of the tread, multiplied by the height of the riser, should equal 66 inches, which will be found to agree nearly enough with the above table, which I have given.

Of course it will be understood that these dimensions cannot always be carried out to the letter, on account of the varying circumstances, lengths, and heights met with in practice; but the principle can be always borne in mind, and regulated to the individual requirements.

The width of the stair or length of the step is also subject to variation, with the different positions and circumstances, but they should never be less than 2 feet 9 inches or 3 feet for ordinary use; and it is better that they should be of such a width that two persons can pass each other on the flight with ease.

In winding stairs, or places where there are winders, the full width of the tread in proportion to the rise should be placed where a person would put his feet when he is grasping the handrail in ascending or descending the stair; that is, about 18 inches from the centre of the handrail, or string.

Kinds of Stairs.—A *straight* stair is that on which the person ascending moves up in the same forward direction from bottom to top, as figs. 798, 799, and 800, in plan, section, and elevation. This is a very common form of stair, though it takes a considerable length of space in proportion to the height to be attained; and on the other hand, it only takes up half the width. It is a very tiring and inconvenient stair when there is a considerable distance to ascend.

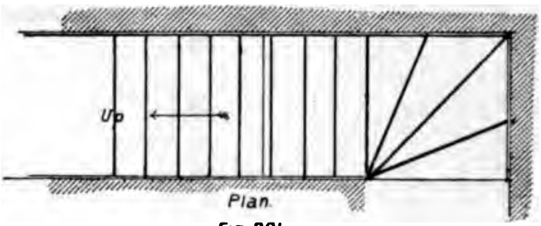
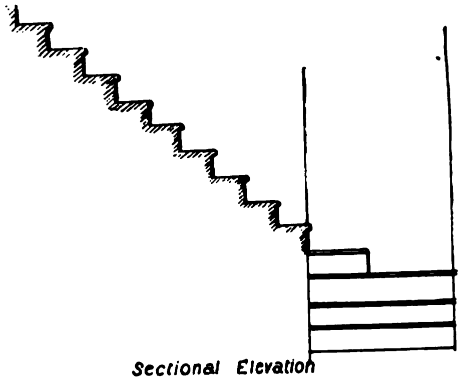
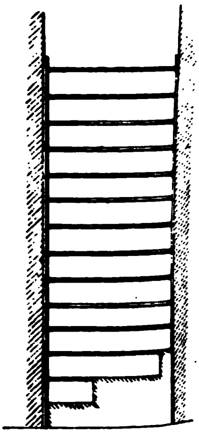


Fig. 801

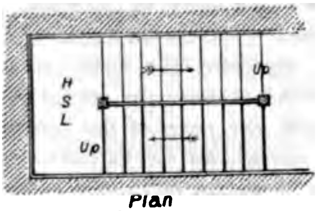

Sectional Elevation
Fig 802


Front Elevation
Fig 803

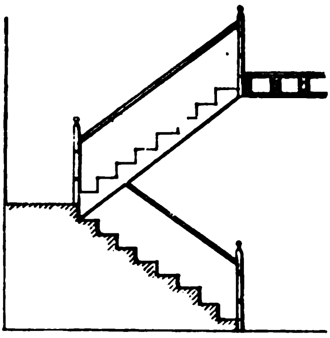
Figs. 801, 802, and 803 represent the same class of stair with winders at the bottom, which create a saving in the length of the staircase, and, when at either bottom or top, necessitate the starting place or landing being almost at right angles to the stair itself.

Winders, though of common occurrence, are an inconvenient defect in a stair, and should always be avoided as much as possible. Straight stairs ay have a landing in their length, to break the flight, and as a resting lace; but it seriously increases the length of the staircase.

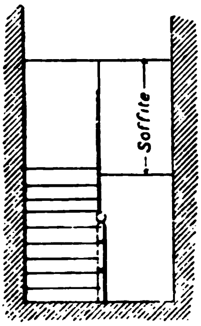
Dog-legged stairs are the first improvement on the latter, inasmuch as



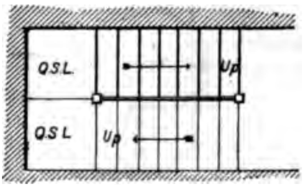
Plan
Fig 804



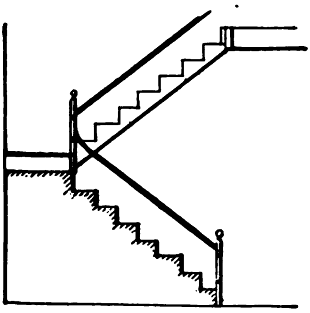
Sectional Elevation
Fig 805.



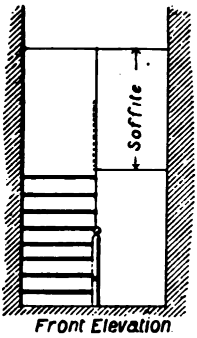
Front Elevation
Fig 806



Plan
Fig. 807



Sectional Elevation.
Fig 808.



Front Elevation
Fig. 809.

by them the distance to be ascended is divided into two flights with a half-space, or two quarters connected by one riser, between each flight, as figs. 804, 805, 806, 807, 808, and 809. It will be seen that the length of the staircase is considerably reduced, while its width is increased; also that the outer string, carrying the outer ends of the steps of one flight, is exactly above that of the other flight, leaving no opening or well hole, as it is called, between them. It is in this kind of stair that the newel is first used, its object here being to receive the top end of the string and handrail of the one flight, and the bottom ends of the other, or top flight. The newels are generally square pieces of wood, but sometimes turned or otherwise ornamented. Figs. 810 and 811 represent the common square newel (used in figs. 807, 808, and 809), which receives the strings of both flights, one over the other, on the first side, the risers of the bottom and top step of the alternate flights on the second and fourth sides, and the riser (X, fig. 811) on the third side, when there are two quarter-spaces in lieu of the half-space landing. The newel reaches in length from the floor below to a little above, where it receives and supports the handrail of the top flight.

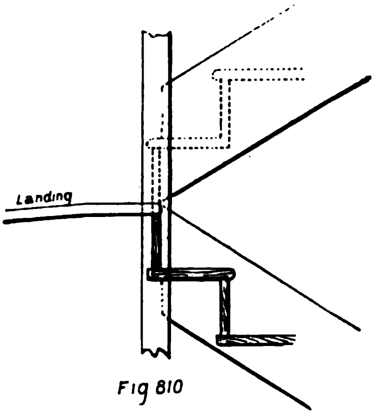
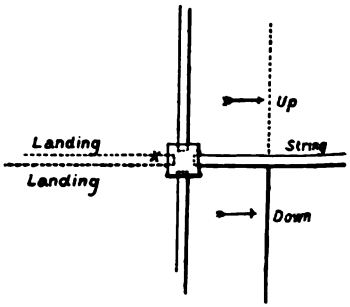


Fig 810



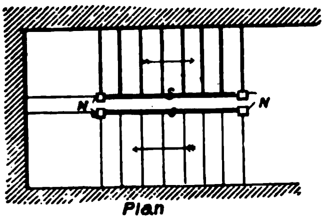
Plan.
Fig. 811.

Sometimes, in dog-legged stairs, the quarter and half-spaces are completely taken up by winders; but this should always be shunned as a most serious defect and danger.

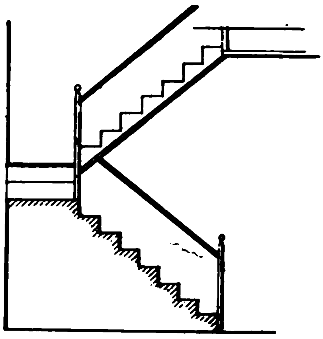
The open newel stair differs from the foregoing, in that it has a well hole between the strings of the two flights, necessitating the use of two newels in lieu of the one at the junction; while it allows of one tread and two risers between the two quarter-spaces, as in figs. 812, 813, and 814.

This is a convenient form of stair, though it takes a wider staircase than the last; but this is more than counterbalanced by its utility, for which reason it is most generally used in decent work. Still, its principles can be misused by the addition of winders in the quarter-spaces, as in the last.

A *geometrical* or *wreathed* stair is one which has no newels. It requires about the same length of staircase as a "dog-legged" or "open newel" stair, but is perhaps a little wider than the latter. The principle of the stair is the continuous string, stretching, or inclining, as it does, from bottom to top, around a well hole, with a half-round corner (still on the incline), where the newels of the open newel stair have been dispensed with.

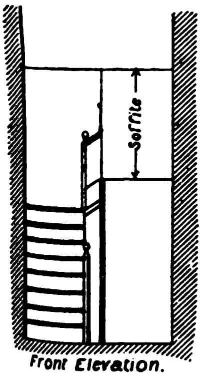


Plan
Fig 812

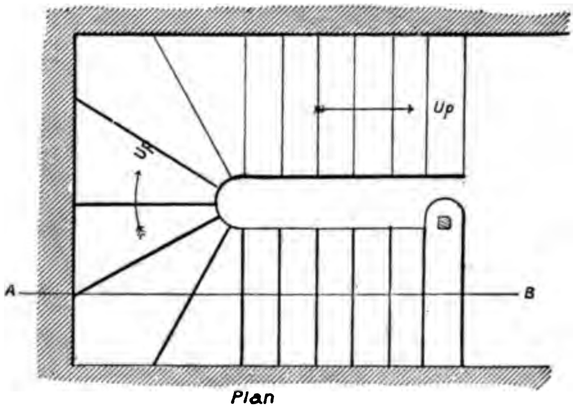


Sectional Elevation
Fig 813.

It has no landings or quarter-spaces, but is one continuous, convenient, and comfortable ascent, the winders converging to points inside the well hole, and thus giving a wide tread, at a very short distance from the wreathed string and handrail. Figs. 815, 816, and 817 give plan, section, and elevation of such a stair.



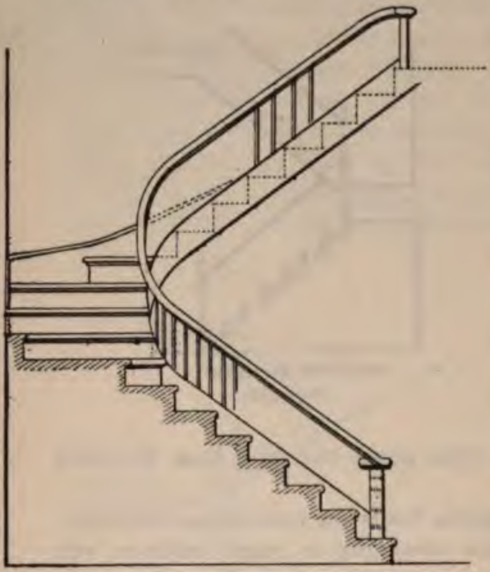
Front Elevation.
Fig. 814.



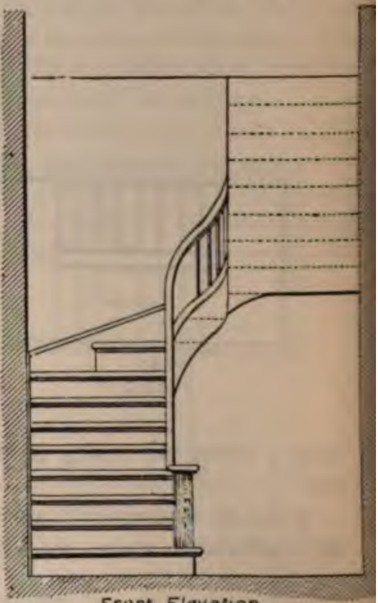
Plan
Fig 815.

Having explained the different kinds of stairs, it now only remains to explain the details which may be said to be applicable to all the foregoing kinds, although there are extra members, and different forms and details of them, peculiar to the more elaborate kind of stair.

Construction of Stairs.—Fig. 818 is a section of the treads and risers of a common narrow stair between two walls. The treads have rounded nosings, and are grooved and tongued to the risers, glued together, blocked and housed into the strings, and wedged up finally.



Sectional Elevation.
on Line A B. Fig. 815.
Fig. 816



Front Elevation
Fig. 817

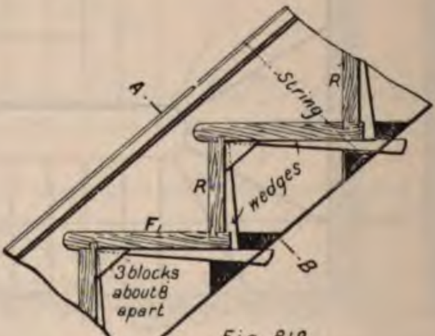
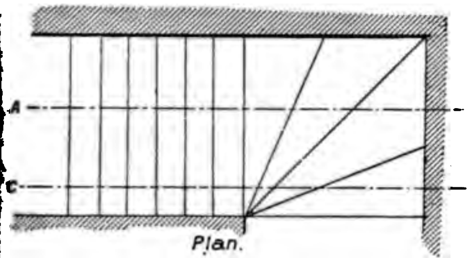


Fig 818.

Winders are similar in detail, but their section depends of course upon where it is taken, and which wide or narrow part of the tread it cuts through, as A B or C D, fig. 819, the latter of which cuts the risers when close together.

Both of the strings, in this case, being wall strings, their sections will be similar to fig. 820, which is a section on line AB in fig. 818. The string is housed out for each end of a step, with its wedges to riser and tread, as fig. 821, in elevation.



Plan.
Fig. 819.

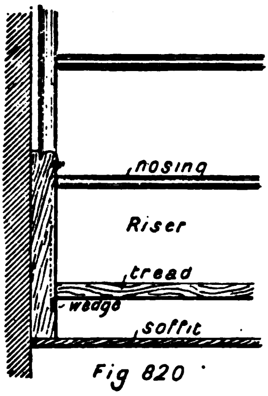


Fig 820

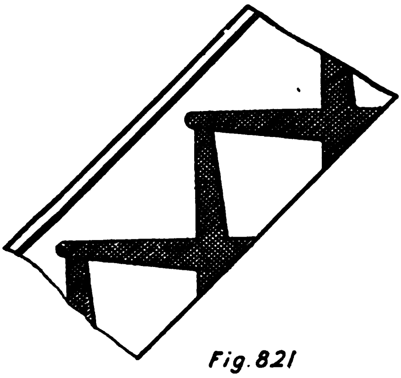


Fig. 821

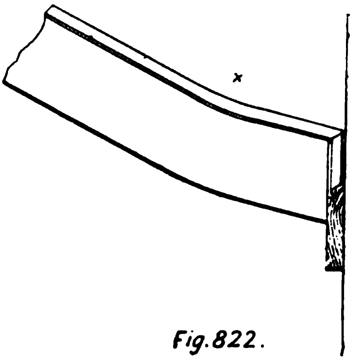


Fig. 822.

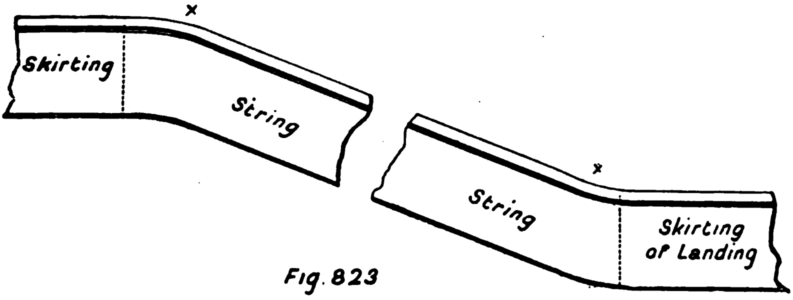


Fig. 823

Where strings meet at right angles they are either grooved and tongued together, or dovetailed; and where there are winders, at either corners, or junctions of raking with straight, they are eased off, as X, figs. 822 and 823, which are called *ramps*.

In better stairs, the section of treads and risers is as fig. 824, from which it will be gathered that the strings are deep, being 11 inches in lieu of 9 inches, and the nosings moulded, the small hollow fillet being housed into the underside of the tread, and dispensing with the tongue on the top of the riser. And in addition to the gluing, blocking, housing, and wedging to strings, where the steps are wide, they have an extra support in the form of a rough bearer called a *carriage*, which inclines from bearing to

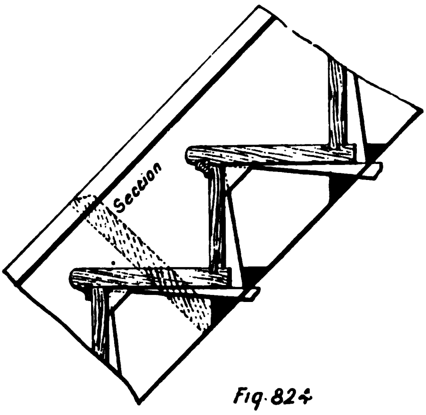


Fig. 824

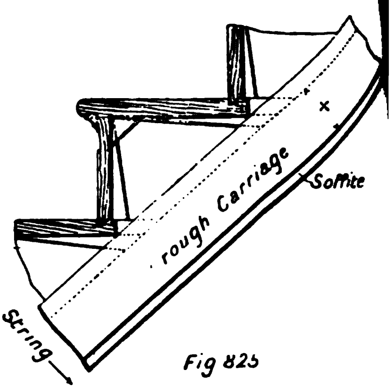
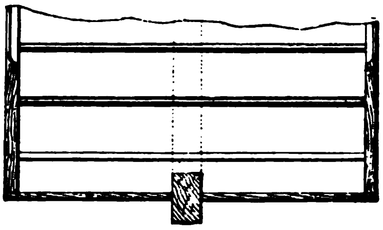


Fig 825



Cross Section
Fig. 826.

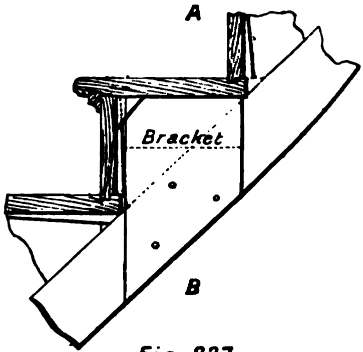
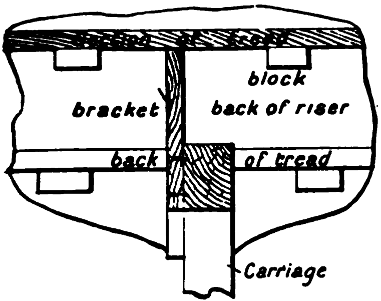


Fig. 827.

bearing, parallel to the string supporting the under-side junction of treads and risers in the centre of the stair, as figs. 825 and 826. This also entails additional depth of string, as X, the top dotted line representing where the underside of the string would have been without the carriage.

Oftentimes a further addition to the "glued, blocked, housed, wedged, and supported by fir carriages," is made by screwing shaped brackets on to the side of the carriage to support the *treads* of the steps, as fig. 827, the carriage only being a help to the risers and the stair, as a body. (See also section, fig. 828.)

When each flight of stair has not a wall on each side of it for wall ings, the other string, which is not against a wall, is called an outer



Section
Fig.828

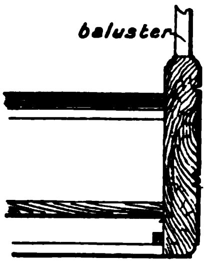


Fig.829.

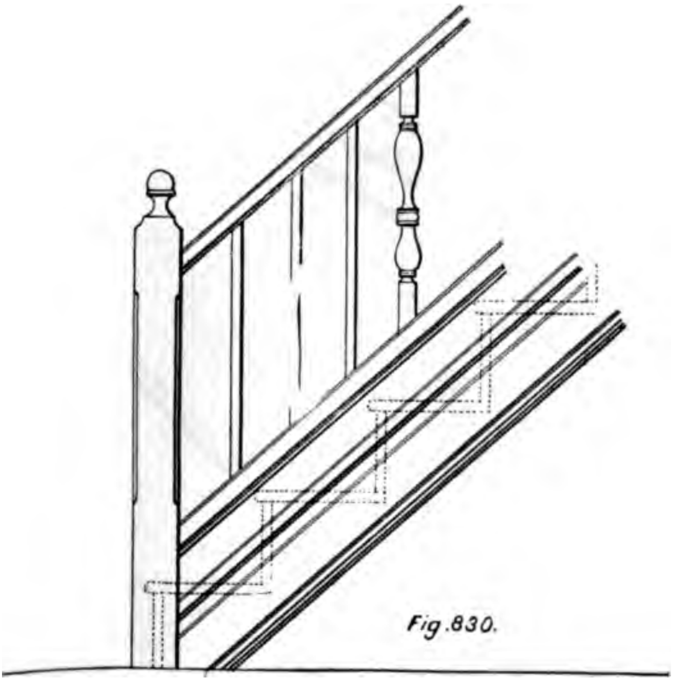
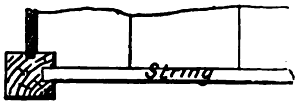


Fig.830.

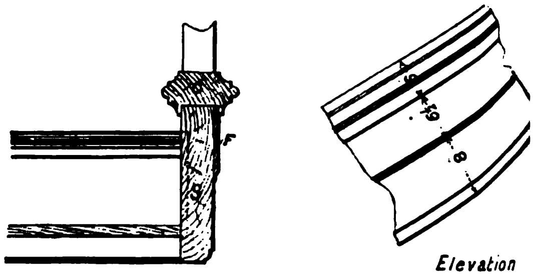
ng. Consequently, it must be stouter, and more ornamental and taking the eye on the outside, as fig. 830, which shows handrail, etc., in vation, fig. 831 being a plan of the same. The string is as fig. 829

in section, or it may be more elaborate still, and consist of string, S; capping, C; and fascia, F; as fig. 832.

Strings should always be tongued at headings, and either grooved and tongued, or dovetailed, at all angles, housed into the centre of all newels,



Plan.
Fig. 831.



Elevation

Fig. 832.

and pinned in, as in fig. 833. If they are moulded the housing has to be scribed for the mouldings to fit in as well.

Handrails are also scribed, housed, and pinned to all newels, and should

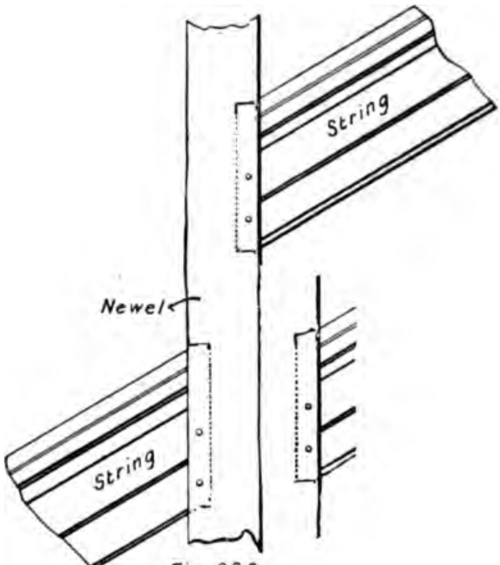


Fig. 833.

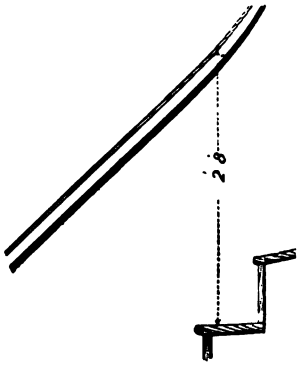


Fig. 834.

be fixed 2 feet 8 inches above each tread, measured in a line from the face of the riser, as fig. 834. On landings and flat places they should be 3 fee 1 inch high. Fig. 835 presents a rounded or mopstick handrail in section fig. 836, a moulded handrail; and fig. 837, a *toadsback* moulded handrail, so called because of its flat curved top.

: *balusters* are housed into the strings and handrail, as shown but sometimes, especially when of iron, they are connected r by an iron core, which is secured on to the top of them, as , and the core, in its turn, is let into and screwed to the underside ıandrail, as fig. 840.

;

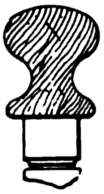


Fig. 836.

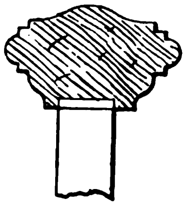


Fig. 837.

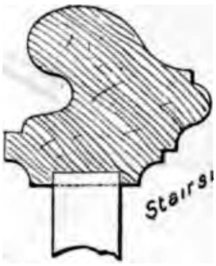
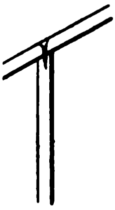


Fig. 838

andrail should always have a curved top face and no arrises, and be a size that it can be easily grasped. Fig. 838 is a section of one : for a winding geometrical or wreathed stair.

vels are generally cut out of square stuff, and either left square, d, or turned. They are the mainstay of the stair and the connecting tween the flights, as every string should be framed and pinned into



.839.

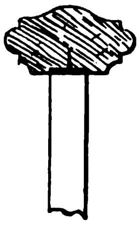


Fig. 840

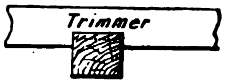


Fig. 841

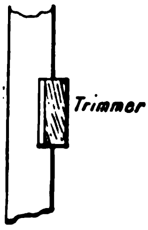


Fig. 842

ıd the risers of the steps next to them ought always to be housed ir centre, as previously shown.

:n newels are not framed at both ends, from floor to floor, they her rounded or turned tops, when their foot is framed and secured ıe bottoms and tops of stairs; and where they occur between ; or flights, and are not framed at either of their ends into floors, t to the trimmers sideways, as figs. 841 and 842, they have a ɪ or turned top, and the bottom is turned and ornamented as well, and called a pendant or drop, as fig. 843, which is a representation of the newels at a half-space landing on an open-newel stair.

Landings, whether half or quarter-space, are made of flooring boards carried on ordinary joists framed into the trimmers, to which one flight inclines, and from which the other starts, as fig. 844, which represents a half-space landing.

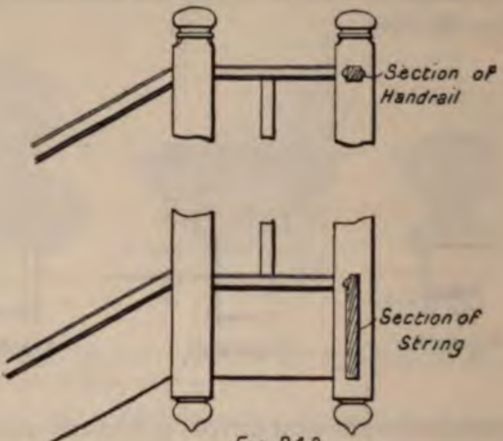


Fig 843

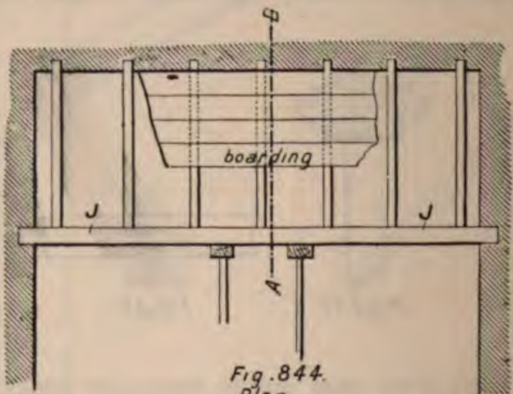


Fig. 844.
Plan.

In best work these boards are not nailed down, but are glued together and secured by hardwood buttons underneath, each button being screwed to the underside of the board, and the tongue on them turned into a groove on the joist of the landing, so that the buttons are secured to the joists, and the boards to the buttons, as figs. 845 and 846.

The edges of the landing are treated as the top of a tread of a step, en they act as such. Fig. 847 represents the edge of a landing above a er, and fig. 848 the edge of a top landing, surrounding the well hole of e stairs ; A, the part which covers the face of the trimmer, being called

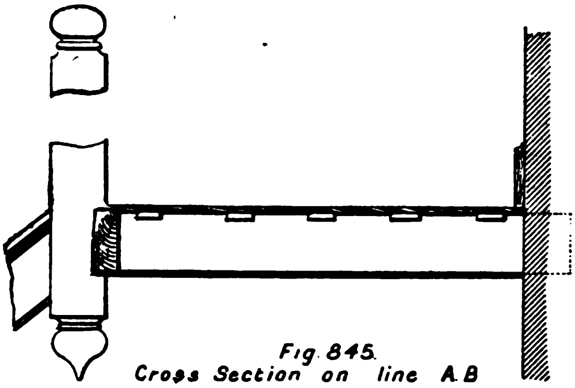


Fig. 845.
Cross Section on line A B

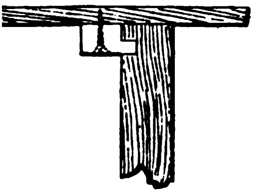


Fig. 846

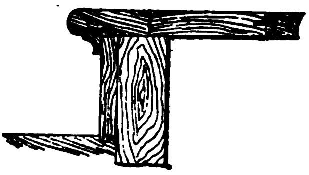


Fig. 847

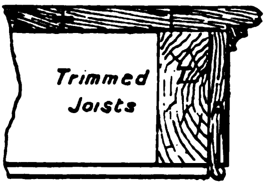


Fig. 848.

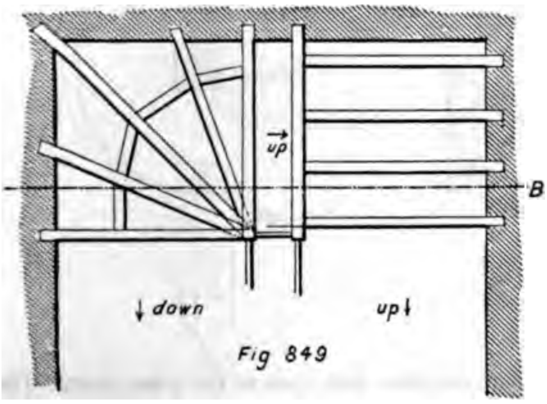
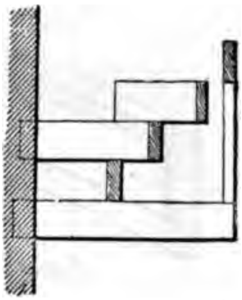


Fig 849


Section on line. A. B.
Fig. 849

an *apron*. Where there are quarter-spaces, it is obvious that one continuous trimmer is neither suitable nor useful, as explained by fig. 849—the right of the figure representing the rough joists and trimmers of a quarter-space in an open newel stair, with two risers between the quarter-spaces, while the left side shows how to place the bearers, etc., when necessary, with winders. The section will explain the different height of the bearers, and should give the student an idea of what is required in such cases. (See fig. 849.)

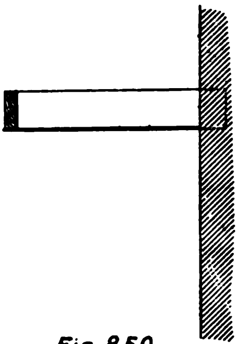


Fig. 850.

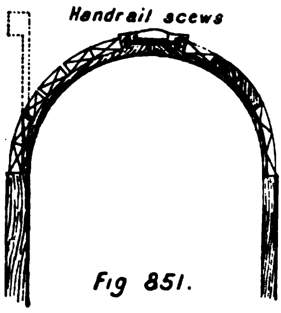


Fig 851.

The bearers for the winders in a wreathed or geometrical stair are treated in a similar manner.

Wreathed stairs (geometrical), with their continuous winding strings, of course are very intricate at the returns; so much so, that the strings and handrail are constructed on a drum, that more accuracy may be obtained, as the string is both circular on plan, and rises at the same time. The back of the string at the return is cut away to a very thin veneer, which is blocked up with wedge-shaped backings from behind; and the joint between the two parts of the string is secured by handrail screws. (See fig. 851.) It must be borne in mind that it rises at the same time as it goes round. (See fig. 852.) Carriages and bearers support the steps.

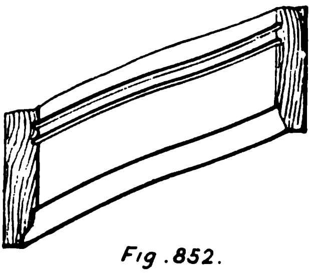


Fig. 852.

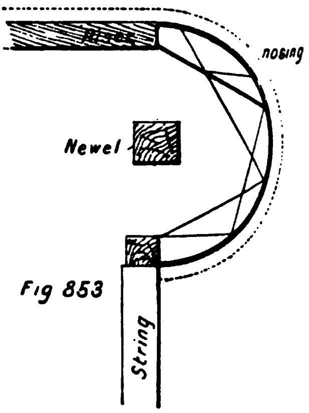


Fig 853

Buil-nosed or *curtailed* steps are treated in the same manner. See fig. 853, which is a plan of one of the latter at the bottom of a stair, showing the veneering and blocking to the curve.

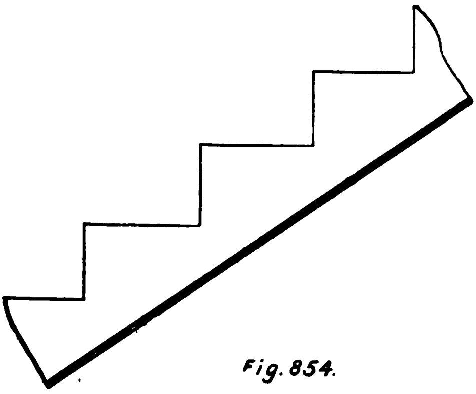


Fig. 854.

Occasionally, in best work, the strings are *cut and mitred*, which is another name for the *open* string; and, at the same time, gives a clue to the class of treatment to which the string is subject.

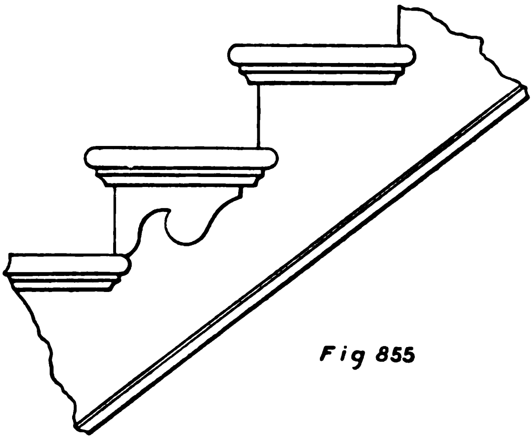


Fig 855

The string (that is, the *outer* string) is cut out to the shape of the steps (fig. 854), the ends of the treads are rounded, and the small moulding is returned, as fig. 855, oftentimes with a small thin cut bracket underneath as a finish.

The mitring part, as the term "cut and mitred" implies, comes in with the risers, which are mitred to the string, as fig. 856.

This kind of string is used chiefly in open-newel and geometrical stairs.

Sometimes, in wooden stairs as well as stone, solid spandril steps are used, being housed into the strings as usual, but dispensing with gluings, blockings, and other framings underneath. The tread is a loose thin slab of hardwood, nailed on to the top of the solid step, as fig. 857.

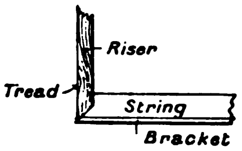


Fig 856

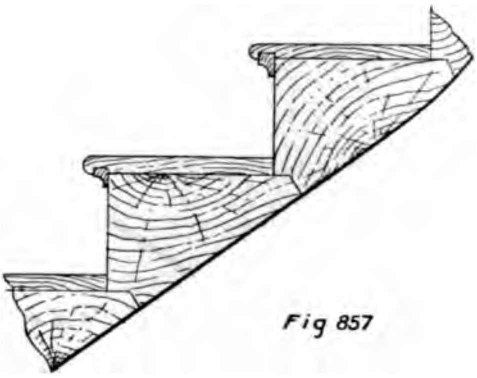


Fig 857

In ordinary stairs the treads are from 1 to 1½ inches thick; risers, ⅞ to 1¼ inches; strings, 1½ and 2 inches; balusters, 1½ to 2 inches square; and newels, 4 or 5 inches square; and the other dimensions, of course, vary according to the circumstances, etc.

CHAPTER XX.

SKYLIGHTS AND LANTERNS.

Skylights—Lanterns on Roofs and Flats—Louvres—Ceiling Lights.

of these classes of framing are used for the purpose of light, either in the roofs, flats, etc., or forming a roof in themselves. Their is to give light from above, where, from various causes and ıstances, the enclosing walls cannot be used to supply that want.

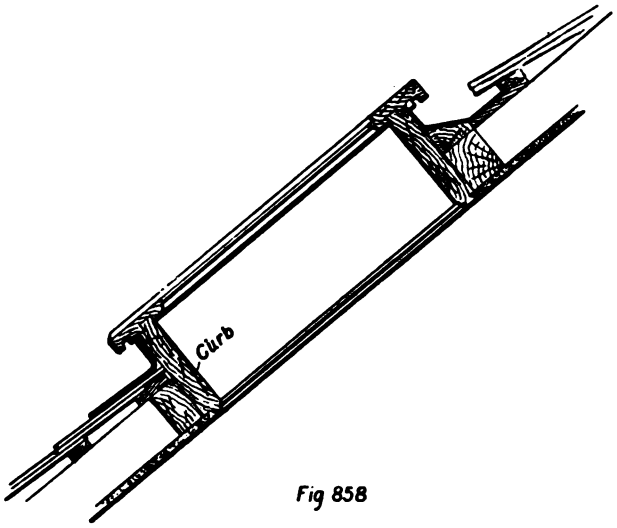


Fig 858

kylights.—A *skylight* is the smaller of the two, and is generally flat m, and inclined with the pitch of the roof; whereas a lantern has l or only slightly inclined sides, which are often framed with casemade to open, in order to give ventilation in addition to light, the being covered by a slated, tiled, or glass roof.

g. 858 represents a skylight in section, fig. 859 the elevation in a slated roof; but only the woodwork will be dealt with in this chapter, no notice being taken of tiling, slating, or leadwork. The student ought to be well acquainted therewith, as they have been explained in previous chapters.

The roof rafters, etc., are first of all trimmed to suit the size of the skylight required, and a curb is framed together and wedged up within that space. The angles of the curb are either grooved and tongued, or dovetailed together; and, in a slated roof, the curb should be 9 inches deep, to allow of a gutter behind it at the top part, as in fig. 858.

In a tiled roof, however, the curb should be 11 inches deep, the increased depth being necessitated by the extra thickness of tiles as compared with slates. The tiles at the eaves of the gutter, which is at the top of the skylight, with a 9-inch curb and ordinary rafters, etc., would almost touch the bottom of the toprail of the skylight, and would not allow of a sufficiently large gutter, especially for snow, hence the necessity for 11 inches.

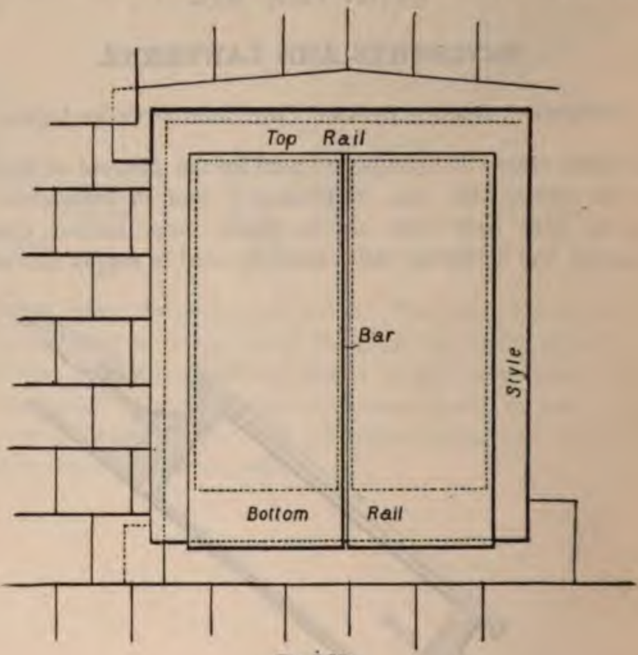
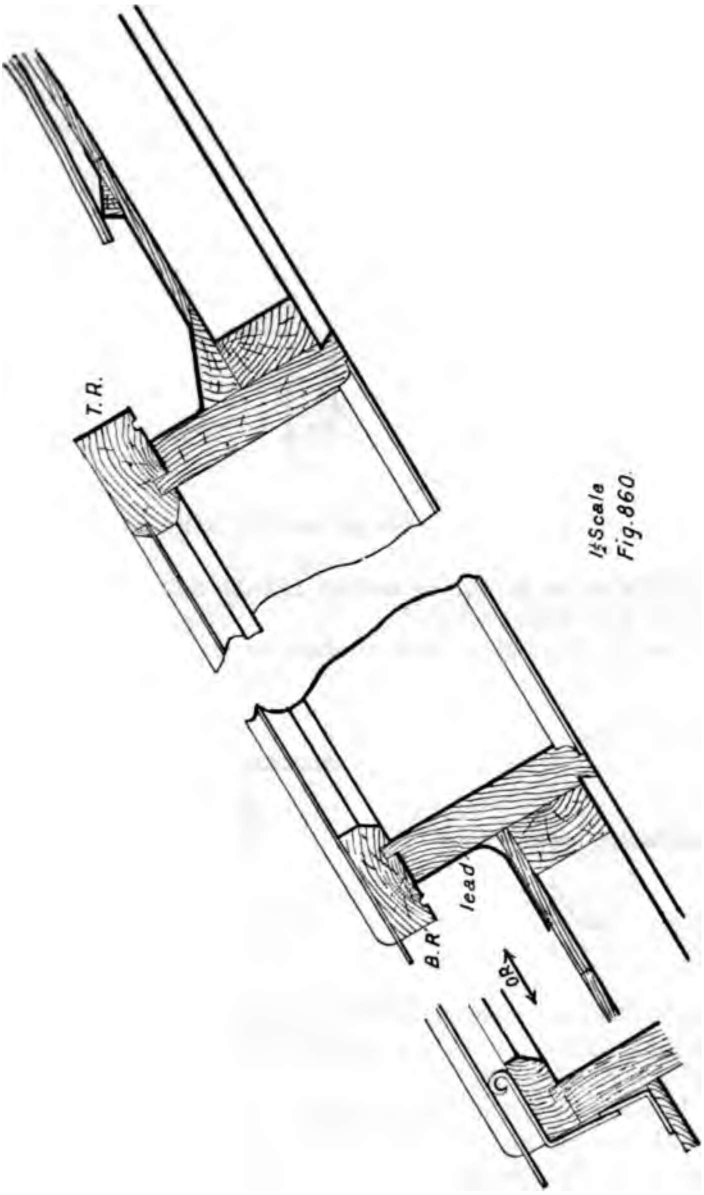


Fig. 859.

The 9 and 11-inch curbs are measured from the underside of the rafters, and if these are of more than the ordinary depth of common rafters, the depth of the curb has to be increased accordingly, but the above are the usual sizes—*i.e.*, 9 and 11 inches deep by 1½ or 2 inches wide.

The top of the curb is tongued, to fit a groove around the underside the skylight, which is a framing of styles and rails, with bars for the



½ Scale
Fig. 860.

glass, running in the direction of the roof, and framed into the top and bottom rail, as will be gathered from fig. 859.

Fig. 860 is an enlarged detail of the top and bottom of fig. 858, from which it will be seen that the bottom rail is not as thick as the top one, being $\frac{3}{4}$ of an inch, or the depth of the rebate, less. This is done in order to allow the glass to run down over it and project over the bottom edge of the bottom rail, so as to throw the rain-water off. Otherwise, if the bottom rail were to be made of the same thickness as the toprail, a gutter would be formed, and the rain would soak through the putty and drop inside; and in snowy weather it would form an excellent lodgment for the snow, as shown on fig. 861.

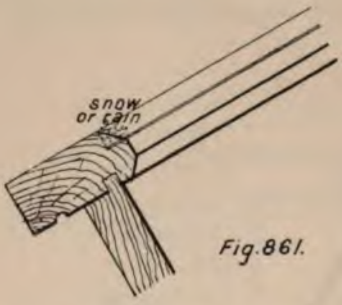


Fig. 861.

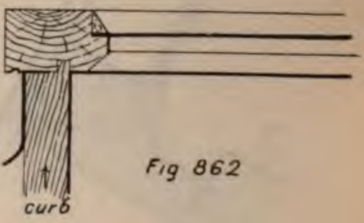


Fig 862

The styles are as fig. 862 in section, and the rails are tenoned and wedged into them at the angles.

The bars (fig. 863), which are fixed about 12 to 15 inches apart, are, of course, of the same moulding as the styles and rail, and of the same depth as the styles and toprails, but $1\frac{1}{2}$ inch wide, and framed at each end into the top and bottom rails.

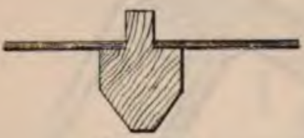


Fig 863

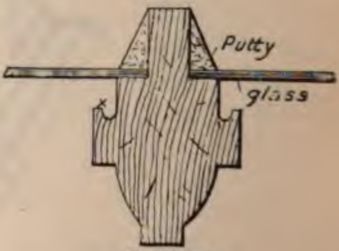


Fig. 864

The bars may be moulded to any section, chamfered, or square; and in best work they are checked out a second time, and grooved underneath the glass, as fig. 864, to allow the condensation which collects on the underside of the glass to run down the bars and out.

Skylights can be either fixed or hung; and in the latter case they are hinged by butts at the top, and opened at the bottom upwards by a patent lifting apparatus (fig. 865).

The glass of the skylight is kept in position by light narrow copper clips screwed to the rails, underneath the glass, which they clasp at the bottom as in fig. 866.

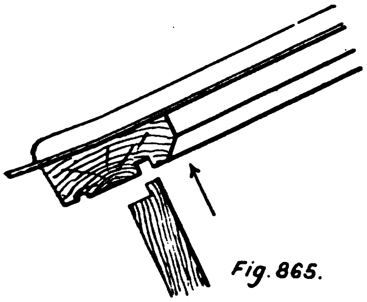


Fig. 865.

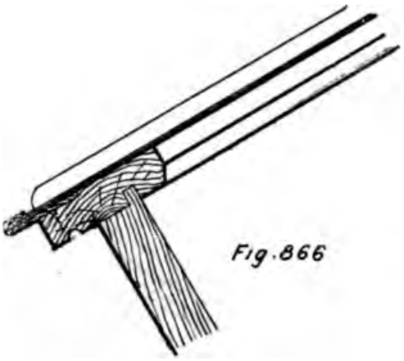


Fig. 866

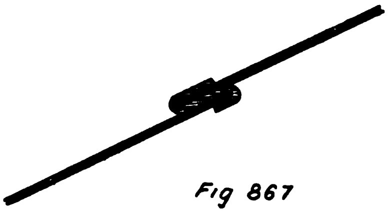


Fig 867

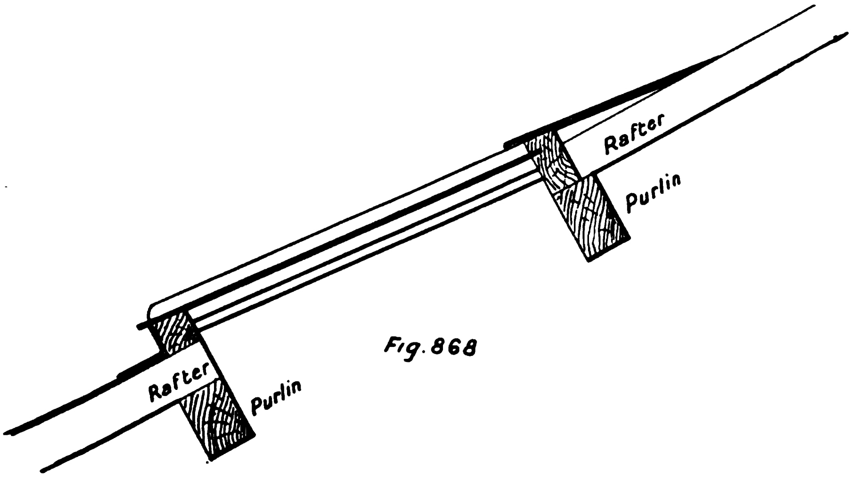


Fig. 868

The glass ought, if possible, to be in one length; but when that is not possible, these clips, with another bend in them, are also used to keep the top pane (which laps over the others) in position, as fig. 867.

In common and very large fixed skylights, over sheds, etc., no curbs are used; but a head and sill to the required section are fixed to the ends of rafters longitudinally, the styles being framed into them at the ends, and the bars stumped into the head at the top, and notched into the sill at the bottom, as fig. 868, which illustrates such a skylight in any position intermediate between the ridge and the eaves.

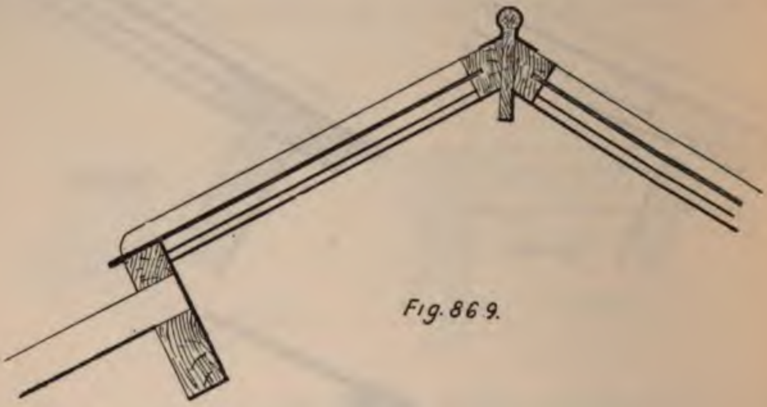


Fig. 869.

Fig. 869 shows a similar skylight, placed close up to the ridge itself, which also may be differently treated, as shown in the enlarged section (fig. 870).

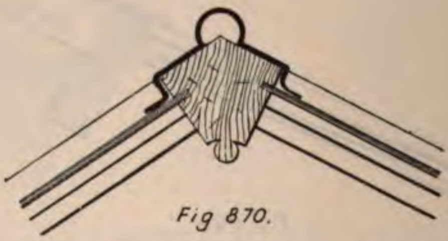
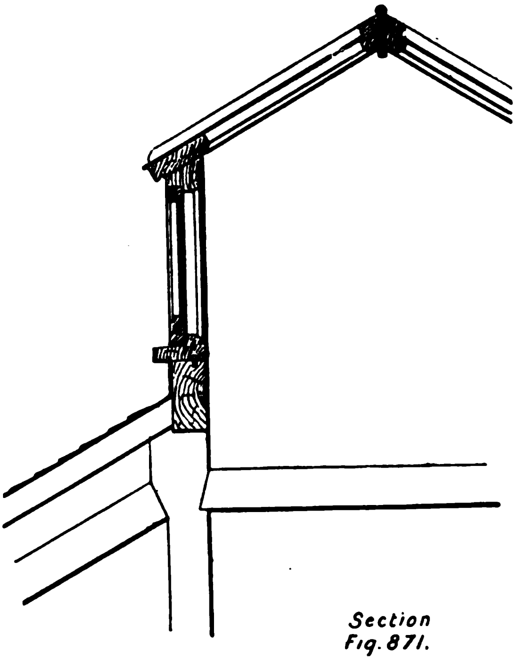


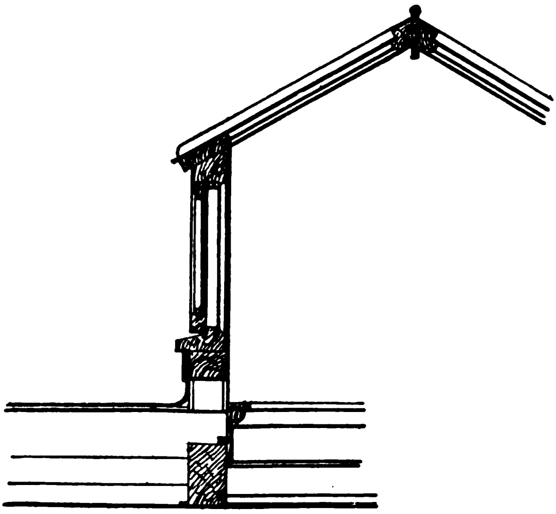
Fig 870.

Lanterns.—Lanterns are generally formed at the apex of a roof, as fig. 871, or on a flat, as fig. 872; their roofs having either gable ends, as fig. 873, or being hipped, as fig. 875.

The top or roof part of the lantern (figs. 871 and 872) is precisely similar to an ordinary skylight, consisting of bars, styles, sills, and heads framed together; the heads of the two sides meeting at the apex, against

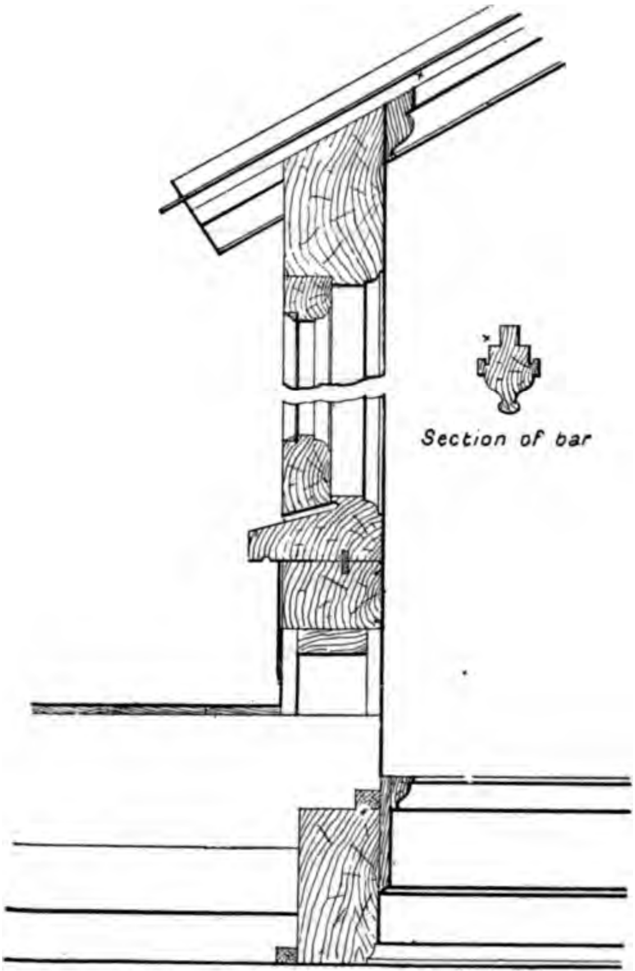


Section
Fig. 871.



Section
Fig. 872

875A, which otherwise represents a lantern on a flat (*vide* also
2).
e side framing consists of four angle posts, framed into head and
ith intermediate mullions, the whole rebated out for, and filled in



Section
Fig. 875A

oulded casements, either fixed or hung, according to requirements,
sements being sometimes hung on centres, or pivoted, as herein-
explained. It is needless to give details of these angle posts,
ns, and casements. The student will be able to form his own details

from the illustrations, etc., already given in the chapter on solid frames and casements.

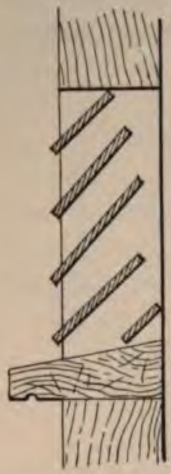
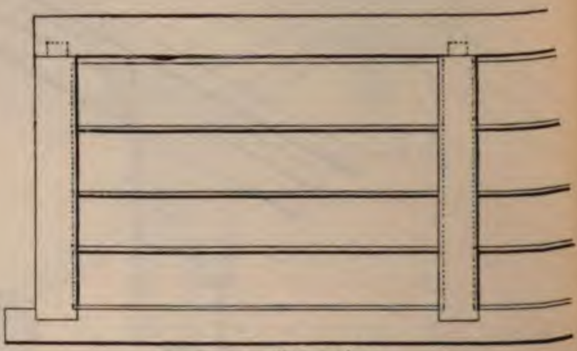


Fig. 876.



Elevation
Fig. 877.

In lanterns for common shed roofs the side framing is often filled in with louvres instead of casements, to give egress to the hot air or steam as shown in fig. 876.

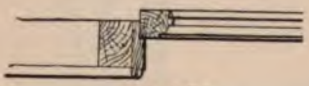


Fig. 878

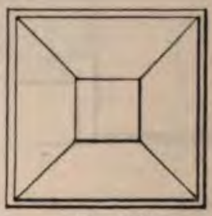


Fig. 879

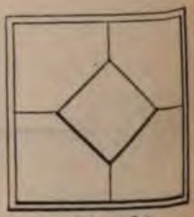


Fig. 880.

The ends of the louvres are housed into the posts or mullions, as fig. 877.

Ceiling Lights are often used, in connection with fixed skylights, to bring the light into the rooms, and still have a flat ceiling. The ceiling rafters are trimmed, and a curb is wedged inside it, rebated out at the top for the casement, which is of the ordinary section and class (*vide* fig. 878). The bars may sometimes be constructed and arranged to some geometrical or ornamental designs, as figs. 879, 880.

CHAPTER XXI.

PLASTERING, PAINTING, AND GLAZING.

Plaster Work Materials—Plaster Work Processes—External Work—Ornamental Work—Glass and Glazing—Patent Glazing.

Plaster Work Materials.—Plastering consists in covering with a smooth surface all rough walls, ceilings, partitions, etc., in the superior apartments of dwellings, etc., where a more finished, better-looking, and more sanitary effect is required. This result is obtained by the use of various materials, including several patents, as will be pointed out in the following remarks on the materials themselves and their application.

The lime used by the plasterer is the *pure* lime, containing only carbonate of lime, and is sometimes called a *fat* lime. It has neither great power of setting nor ultimate strength, is of a white colour, and slakes very freely; and immediately the water is poured on it a great volume of steam will arise, and the lime will begin to crack very loudly, if it is of the best kind for plastering.

Such lime is found at Crich, Buxton, and Dorking, being the product of burning either marble, white chalk, or the Bath and Portland oolites of various places. By the slaking process pure lime will increase in bulk to three times its original cubical contents. When the slaking is completed the lime and water are run through sieves, to collect and screen out the hard unslaked lumps or residue, which would be a source of danger in the finished work. The creamy mixture of slaked lime and water is called *putty*, and in this state, to ensure perfect slaking, some limes should be kept for a period of one or two months before being used.

The sand used for plastering must be clean and sharp, free from all earthy or vegetable matter, and washed, if necessary, to eliminate all these impurities. Pit sand is far preferable to that taken from large river beds, where the sand is continually kept in motion by the currents, so that the particles or grains are rounded, which takes away their sharpness.

Plaster-of-Paris, used for gauged stuff, is calcined gypsum, which, after being mixed with water to a paste, sets quickly and with a smooth hardened white surface.

Portland cement, which will be dealt with more fully in Chapter XXIII., is chiefly used for outside work, the lighter (in weight) and quicker-setting qualities being the most suitable for this purpose.

Keene's cement is Plaster-of-Paris, saturated with *alum*, and is chiefly used for angles, pilasters, and the more ornamental parts of plastering, for internal use only.

Parian cement is a finer-working substance, used for large surfaces of a better class in internal plastering, the walls generally being first backed up or rendered over with Portland cement and sand, in preparation for the Parian, which is really Plaster-of-Paris recalcined, with *borax* added.

Martin's cement is similar to the last in preparation, *pearl ash* being used instead of borax, which produces a "fatter" cement, forming (like Keene's) a better "arris."

There are several other kinds of cement of these classes, but they are so seldom used in ordinary work that it is unnecessary to describe them.

The *laths* used for plaster work (fig. 881) are thin strips of wood, about 1 inch broad and up to 4 feet long, rent or sawn out of good fir or oak; and the different thicknesses are classified as below:—

Single lath	are about	$\frac{3}{16}$	of an	inch	thick.
Lath-and-half	"	$\frac{1}{4}$	"	"	"
Double lath	"	$\frac{3}{8}$	"	"	"

Plaster Work Processes.—*Brick and stone walls* are—as it is termed—covered by "two" or "three" coat work, consisting of a *rendering* or *pricking up* coat, a *floating* and a *setting* coat.

The first consists in covering the walls roughly with the patent materials specified, or with the *coarse stuff* (otherwise called "hair mortar") in common and ordinary work, consisting of the properly slaked fat lime, mixed wet with about three parts of good, clean, sharp, washed sand, and a proportion of good well-beaten cow-hair. This mixture is then applied to the walls, to the thickness of about $\frac{1}{2}$ an inch, or as may be required to make the wall surface perfectly plumb and level. So soon as the coat begins to dry it is scored over or scratched to give the next or floating coat a key or means of attachment.

When this first—rendering or pricking-up—coat has become dry, the second or *floating* coat is applied on it to a certain thickness, of from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch. This coat consists of a better and stronger mixture of the same materials as the first, but with less hair, called "fine stuff." The surface of this coat is made truly even in every way following on the last by means of perfectly plumb, vertical, and horizontal *screeds*, laid on the walls to the required thicknesses, and about 6 inches wide, at the angles, ceiling, and skirting, and intermediately, as the straight edges, with which the spaces between are regulated, require.

This second coat is left rough from the *float*, as the tool used is called; and when it becomes dry the third or setting coat is applied, consisting of a very thin film of *fine stuff*,—*i.e.*, "putty," or slaked lime, with a very small admixture of sand, made to about the consistency of good cream. This is applied and worked up to a perfectly smooth and level face, which sets quite hard; after which it is left to dry, and the work is complete.

When a wall is intended to be painted it is finished with a *trowelled* face (for which purpose various other special plasters are sometimes used, to give it a better hardened face), the workman using a steel "trowel" for this purpose, instead of the wooden one, called a "float."

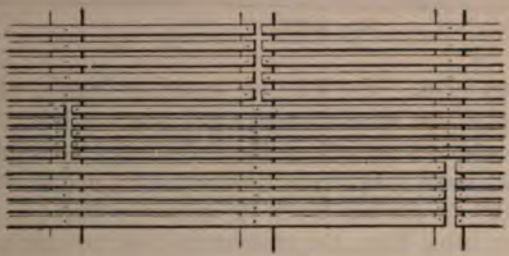


Fig 881.

Two-coat work consists of an amalgamation of the first two coats, finished off with the setting coat.

Walls are sometimes *battened*; that is to say, thin battens are fixed to plugs, vertically up the walls at about 16 inches, centre to centre, to receive the lath-work (fig. 881), as will be explained for partitions and ceilings. This "battening" is used for damp walls; but, while it gives a free circulation of air behind the plastering, it brings with it a greater evil, inasmuch as, besides being subject to decay, it forms a harbour for all kinds of vermin; and rooms with battened walls are made quite lively by the noise of mice and other such creatures. For the same reasons walls behind skirtings, etc., should be rendered up. In elevation, lathwork on battens looks exactly like lathwork on partitions or ceilings; the only difference appearing in the plans or sections, which in this instance are represented by fig. 883.

Counter-lathing or *brandering* is similar to the above, and consists of ordinary laths laid about 16 inches apart on wood lintels, etc., to throw out the laths so as to allow of a key for the plaster work laid on them, over doors and windows and other openings spanned by wood, to which ordinary plastering will not adhere.

Ceilings and *partitions*, *battening*, and *counterlathing* are treated as fig. 881, fig. 882 being a plan of the partition; and the work is specified, for two-coat work as ***lath*, *plaster*, *and set***, or ***lath*, *float*, *and set***, and for three-coat work as ***lath*, *plaster*, *float*, *and set***, consisting of the same proceedings in laying on the material as for walls, with the "addition" of the "lathwork," which means the covering of the surfaces with laths of various thickness (as previously described) nailed to the framing at about 16 inches from centre to centre; the laths being parallel to one another, and about ⅜ of an inch apart, to allow of a key to the pricking-up or first coat of the plastering, which is pressed on to the lath and through the crevices to form a key. The laths are in various lengths up to 4 feet to suit the spaces of the wood framing; and where a joint is necessary it should not be perfectly vertical up the wall on the same piece of wood, but they should break joint every half-dozen laths, and so on, as fig. 881. "Lath and half" are the best to use for ordinary work.

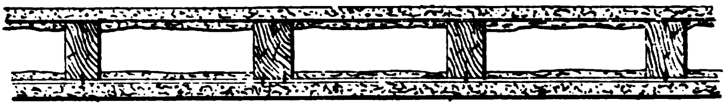


Fig. 882.

This lathing being done, the plastering is laid on exactly the same as on the walls, but it should be pointed out that the first coat takes much longer to dry, having no absorption to assist the drying process on laths, as is the case on walls.

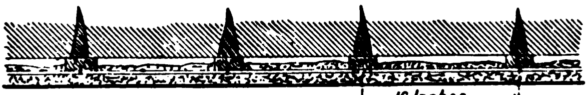


Fig. 883.

All external angles should be roughed up either in Portland or Keene's cement, to make a good hard finish, as ordinary "hair-mortar" and "putty" have no strength for such positions; or "wood angle-beads" should be fixed to plugs in the joint, up the angle, and the plastering *quirked* up to it, as explained under "Joinery" (Chapter XVI.).

When requisite, the plastering to walls, ceilings, partitions, etc., as above, can be made to dry quicker by the addition of a proportion (about one-fifth) of "plaster-of-Paris" to the ordinary mixtures for the various coats; and this is called *gauged* work. The proportion of plaster regulates the time of setting; but it is unadvisable to hurry the work of plastering, and certainly not by "gauging," which is apt in time to cause the whole surface to crack, almost like a spider's web.

Selenetic lime is a mixture of hydraulic lime and plaster-of-Paris, often used for ordinary plastering; its advantages being that it is quicker in setting between the coats, and will take more sand, which renders the mixture cheaper; but it should be mixed according to special instructions from the manufacturers.

Robinson's Patent Paragon Cement (made near Whitehaven), *Adamant*, and *Adamantine* are all patent mixtures for plastering, invented and introduced for the purpose of saving time in the drying of ordinary plaster, and with other advantages, such as a better and harder-finished surface, and the properties of being fireproof, and so adhesive and cohesive as to obviate cracked ceilings and the like objectionable but unavoidable results. They are said to be as cheap as the ordinary plastering, though this has to be proved, as a general thing instead of an exception; but the advantages conferred should be worth the extra cost. A very superior and economical covering to internal walls is to float them in Portland cement and sand, and finish white with "Albino," the best quality of Adamantine.

External Work.—External walls are coated in a similar manner to the internal walls, as already explained, with the exception that Portland cement is used instead of "fat" lime, which will not withstand the weather; and they may be finished off in different manners, the chief of which are here given.

Rough-cast has a rough face, made by the last coat consisting of coarse grit.

Ashlar is the lining up of walls, so as to divide the face into rectangles, similar to ashlar or other stone facing.

Stucco is a general term, used for the rough mixtures, whether with cement or lime, cement-covered external walls being often said to be "stuccoed"; while "trowelled stucco" for internal work is a smooth face, worked with fine stuff without hair, in ordinary plaster; and "bastard stucco" contains hair.

Depeter has a more roughened face than rough-cast in external cement plastering; the effect being obtained by small pebbles, which are pressed in while it is setting.

Depreter is a finish to the same cementing, made to imitate tooled stone.

Scagliola is an imitation of marble, in pilasters, etc.

Ornamental Work.—*Cornices*, and other ornamental mouldings, used to break the angles of apartments, etc., are "run" in plaster by means of "horsed mouldings," running on a wood ground fixed on the wall, truly horizontal, the required depth of the cornice. Ordinary cornices are backed or roughed up with a stronger mixture of coarse stuff, to make it set quicker; and when this has been worked to the right contour it is finished off with plaster-of-Paris, which gives it a hardened white face, with good arrises, where required. When moulded cornices are too big to allow of this backing up being well and properly done in rough stuff, they are *scotch-bracketed*, as fig. 884, which consists of laths cut to lengths and fixed from wall to ceiling, to take off the triangular space shown, and fill up the angle to save material.

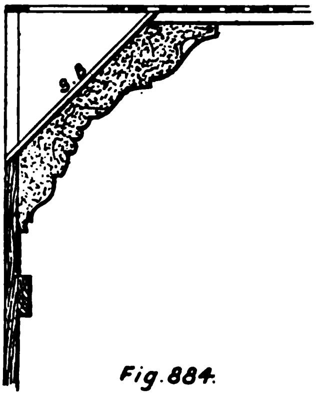


Fig. 884.

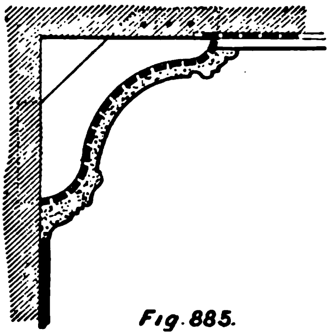


Fig. 885.

As the cornices increase in size beyond this, it becomes necessary to use *wood bracketing*, which consists of wood brackets, roughly cut to the required shape, and fixed, 16 inches apart, to the ceiling joists and wall, and on these the laths are nailed longitudinally for the plastering, as shown in fig. 885; though sometimes the brackets are so large that they have to be built up in parts and framed together, as fig. 886.

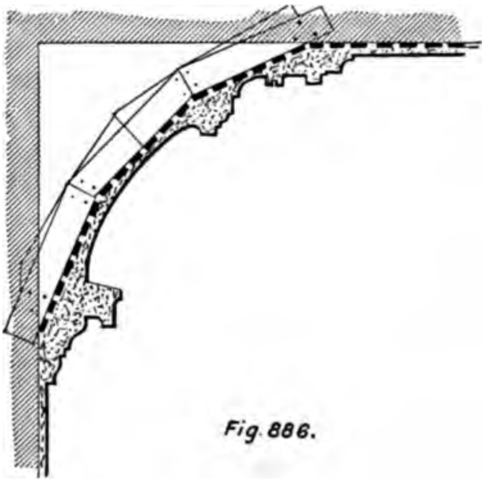


Fig. 886.

Enrichments in plaster are cast in moulds made in beeswax, modelled to the required design.

Papier Maché or *Carton pierre*, as the name implies, is a paper composition formed into the required moulds and ornaments.

Fibrous plaster is a patent, now very much used, consisting of slabs of various sizes, fixed with zinc nails to the woodwork, and covered over with a setting coat about ⅛ of an inch thick. Of this appliance, "Hitchin's," "Jackson's," and "Wilkinson's" are the best-known qualities.

Plaster work is often painted, or treated by the following processes :—

Whitewashing or *limewhiting* consists of two coats of "fat" lime slaked to a white liquid, and applied with a large brush; it is only used in common work, and for sanitary purposes.

Whitening is a mixture of size and whitening, applied in two coats to internal work only, such as ceilings and walls; and when any colouring matter is added it is called "distempering," the surface being first *clearcoled* or *claircolled*—*i.e.*, covered with a solution of glue and alum, which fastens the colour, as it were.

Colouring, applied to both external and internal work, consists of ordinary whitewash, mixed with different colouring matters. "Duresco" is a patent washable covering of this class.

Painting.—*Painting* is the covering of wood, iron, plaster, or other materials, either for the purpose of protecting them or for ornament.

The ingredients employed in the various mixtures used for the different kinds and coats of painting include the following materials :—

White lead, called a "base" in painting work, is a carbonate of lead formed by combining carbonate fumes with the pure lead, by the process of corrosion with acetic acid, the resulting residue being a white powder, which is either sold in that condition, or, more generally, when ground in linseed oil to a pasty consistency.

Red lead is made from oxide of lead, and can be either procured dry or in oil, like white lead. It is used as a drier, for painting iron, or for the first coat, called "priming," on woodwork.

White lead is more used than red lead, being more easily converted into various colours; while it is very dense, and forms a strong permanent covering or protection, being of a good "body" as it is called.

Oil and *turpentine* are called "vehicles" in paint, because they (figuratively speaking) "convey" the lead on to the surfaces to be covered.

Linseed oil, of a *drying* kind, is used very greatly in the mixing up of paints, it having the property of being ductile, while it will also dry well and form a good coating.

Turpentine is really an oil extracted from the pine tree, and used to make paint work more easily, and for *flatting* coats internally, it having a dull effect, in comparison with the linseed oil.

Driers, whether in the form of Litharge, commonly called oxide of lead, or "patent driers," are used to make the oil set all the quicker in forming a coating.

The colouring of paint is done by the addition of various ochres and vegetable matters of different colours called "pigments."

The proportions in which these bases, vehicles, etc., are mixed may vary according to circumstances, and the coats applied, being generally in about the following ratios:—

First coat or priming—14 lbs. white lead, 1 lb. red lead, 6 pints linseed oil (raw for inside, boiled for outside), ½ lb. driers.

Second and third coats—14 lbs. white lead, 3 or 4 pints oil, 3 pints turpentine, ½ lb. driers.

Fourth coat—14 lbs. white lead, 2 pints oil, 4 or 5 pints turpentine, ½ lb. driers.

Woodwork, intended to be painted, comes from the joiner's shop, generally, ready smoothed and clean, so that the first proceeding is to *knot* it—*i.e.*, to cover the knots over with size, or patent knotting, to kill the turpentine in them, and so prevent them spoiling the finished work. The whole surface is then *primed* with red lead paint, which satisfies the absorption of the wood. It is then rubbed down with pumice stone, all holes are filled up with putty, and any unevenness obviated, in preparation for the second, third, and fourth coats, each coat containing less oil and more turpentine than its predecessor. Good work should be rubbed down between each coat, which gradually approximates to the finished colour as described, and the final coat very often, from its tint, allows of little lead or body being used.

For ordinary new work the words of the specification are:—"Knot, stop, prime, and paint three oils or coats in best white lead paint"; the only difference between inside and outside work being that "boiled oil" should be used for all parts that are exposed to the sun.

Old work should be well "cleaned, rubbed down, and stopped" before the coats are applied in the ordinary way.

Varnishing is the process of coating plain or painted work with a colourless material called "copal varnish," a mixture of resin and oil or turpentine, which forms a very hard, glossy, and durable coating.

Graining is an additional coat of paint applied on the ordinary four-coat work, and marked or scratched over to imitate the grain of oak and other woods.

Ironwork should be painted with oxide of iron paint, as the lead in the ordinary mixture is said to cause an injurious galvanic action between the two metals.

Glass and Glazing.—*Glass* is a transparent material, used for giving light through openings, while excluding the elements. It is a mixture of white sand, soda, and chalk, in various proportions, melted together at a very high temperature, and then formed into the various kinds required. These include "crown," "sheet," and "plate" glass.

Sheet glass, the most useful variety, is made by blowing the heated glass into cylinders, which have their ends cut off and periphery split down, so that the glass can be flattened out in a kiln, under the action of heat, applied to open it out, after which it is allowed gradually to cool. The various kinds of sheet glass are distinguished by their weight per foot, super., as 16 oz., 21 oz., 26 oz., and 32 oz.

Plate glass is, of course, a superior kind, made of thicknesses varying from $\frac{1}{8}$ inch to 1 inch, by which thicknesses it is described and distinguished. In the process of its manufacture the glass, when at a white heat, is placed on a table and rolled to the required thickness; after which it is polished over or left as *rough-cast*. Its advantages over "sheet glass" are that it is much stronger and less affected by atmospheric influences, while it cannot be cut noiselessly with the diamond—which renders it an enemy of burglars.

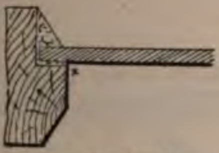


Fig. 887.

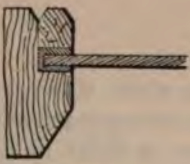


Fig 888

Rough-cast—the resulting material without the polishing—has a rather wavy appearance, but is otherwise as strong and advantageous as the polished plate.

British polished plate glass is even superior to the ordinary "polished plate," though of the same material; its superiority being the result of grinding the surfaces down truly before polishing.

Hartley's rough rolled plate is of similar composition to the "plate," but it is rolled on a patent ribbed table, which gives it the advantage of admitting light without scorching, glare, or diminished transparency.

There are numerous other varieties of glass, chiefly made out of the different manufactured products above explained, and rendered different by the labour and colouring matters expended on them and used therewith.

Glass is cut into squares or panes of the required size, and secured by means of putty (a stiff, pasty substance of whiting and oil) into the wood or iron rebates, as fig. 887, which shows the glass puttied and *back-puttied*, as at X; or it is secured and bedded in washleather, by means of wood fillets or beads, as fig. 888.

As the putty used in glazing cannot be made of a suitable lasting material, but is perishable, the necessity has arisen of late years of employing other means of securing the glass to the framing, especially in skylights and other exposed flat or sloping surfaces.

A simple method of attaining this object is to secure it by sprigs driven into the woodwork at the bottom of the sheet and at the sides, as fig. 889, in addition to which, if the glass is cut circularly on the bottom edge, all water will be collected, and will run down the centre of the light clear of the putty and bars, as shown by dotted lines.

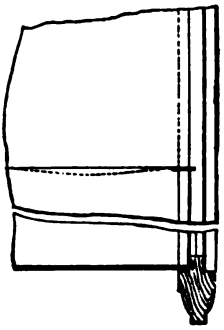


Fig. 889

Patent Glazing.—Among the many patented methods of accomplishing this result, now in vogue, may be mentioned the following:—

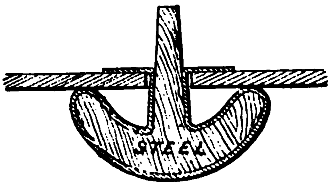
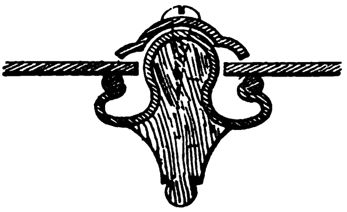


Fig. 890.



ig. 891.

The British Patent Glazing Company's Patent, consisting of steel bars and sheet lead, as illustrated by fig. 890, from which it will be seen that no water can enter and drop through their system, as any water penetrating between the bars and the lead is collected in the groove of the bar.

Messrs. Braby's Patent, consisting of wooden bars of any size and design, and zinc, etc., is illustrated in section by fig. 891.

Messrs. Grover's *Simplex* is shown in figs. 892 and 893, from which it ill be seen that their method consists of a patent lead strip, as fig. 892, xed to wood bars and turned down on the glass, as fig. 893.

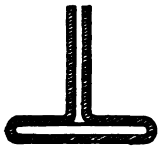


Fig. 892.

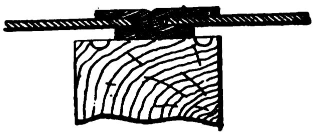


Fig 893.

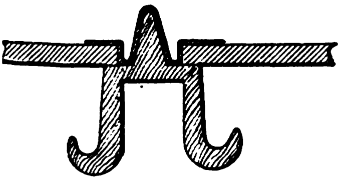


Fig. 894

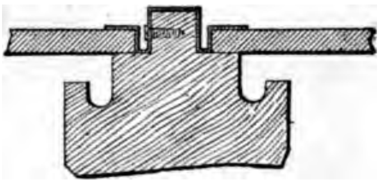


Fig: 895.

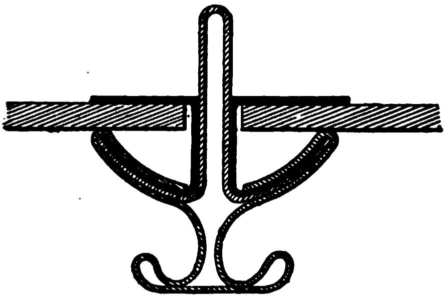


Fig 896.

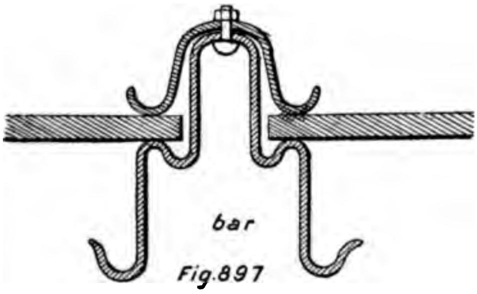
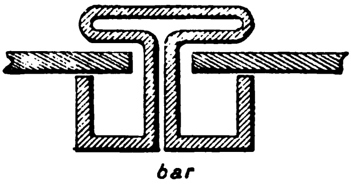


Fig. 897

The *Pennycook* Patent is illustrated by figs. 894, 895, and 896, from which it will be seen that this system can be adapted to iron, wood, or metal bars.

Helliwell's Patent consists of metal bars and capping, as fig. 897, and Rendell's of similar materials, as fig. 898 in section.

There are many other similar patents, including that of Messrs. Mellowes (of Sheffield), which is extensively used throughout the country, though those above illustrated are quite as good and effective.



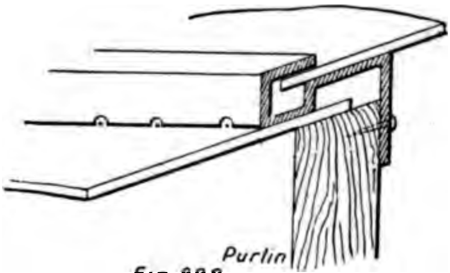


Fig 898

Duroline is a substitute for glass in positions where glass would soon be broken. It consists of thin wire-woven work, covered over by a transparent thin substance of different tints. It is fixed on rafters by zinc nails, and lapped at the joints.

CHAPTER XXII.

CENTRING, FOUNDATIONS, SHORING, SCAFFOLDING, SEWERS.

Centring—Foundations—Different Soils—Sewers—Shoring and Strutting—Scaffolding—Hoisting Tackle—Underpinning.

Centring.—Centres are framed structures for temporary purposes, used in throwing arches over apertures, etc. They have their top shaped to the required curve of the arch, are made specially for the dimensions of the opening, and act as a support to the constituent parts of the arch during construction, and until each member has taken its proper bearing, and the whole has become one solid mass.

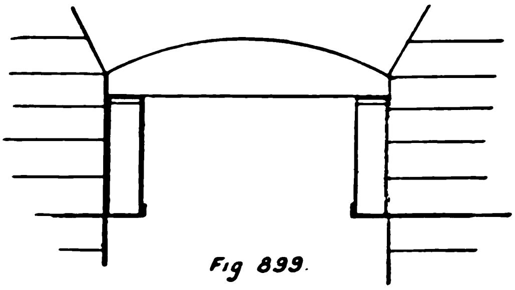


Fig 899.

For small arches, and only 4½ inches deep on soffit, a wood *turning-piece* is used—*i.e.*, a strong piece of wood about 3 inches wide is cut to the required curve of the arch, and fixed just below the springing, generally by means of bricks held up by nails driven into the joints of the reveals, as fig. 899.

For openings of a larger size the centres are formed of two outside pieces, cut to curve, and with small pieces called *laggings* nailed at right angles to their faces across the top, as fig. 900, while the bottom is secured in a similar manner, the whole being frequently fixed by bricks in precisely the same manner as last explained, though when of larger sizes they are *horsed up* by upright supports strutting up, as it were, from the sills or other flat horizontal surfaces below, as shown on the illustration.

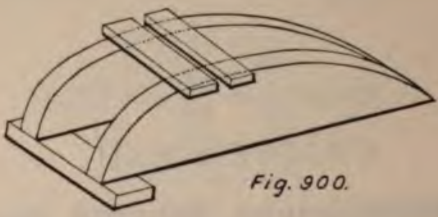
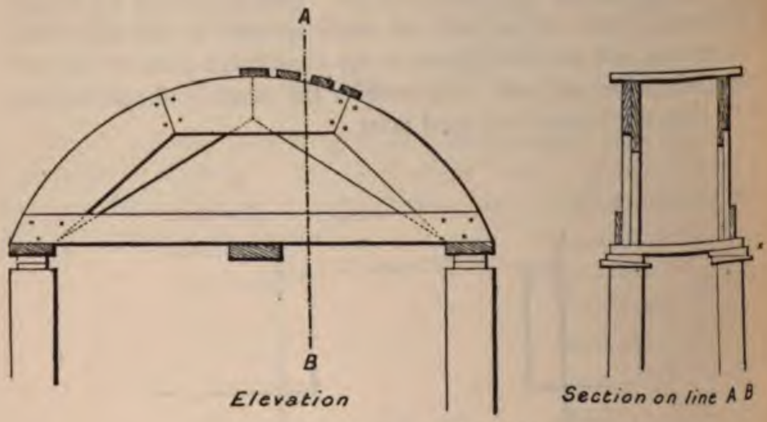


Fig. 900.

The centre itself is raised into its exact position by means of two wedges driven together and placed on the horizontal piece across the support, or on the supports themselves, or bricks at each springing, as at XX on fig. 901. For rough arches these laggings, of about ¾ inch × ½ inch in size, are spaced at about their own width apart; while centres for faced work, and especially for rubbed and gauged arches, must be *close-lagged—i.e.*, their lagging must butt up to each other and the arrises eased off, to give the line a true unbroken curve.



Elevation

Section on line A B

Fig 901.

When the opening is so wide and the rise so high that the curved ribs (to which the laggings are nailed) cannot be cut out of ordinary-sized stuff, the centres have to be built up by lapping and nailing two thicknesses together to make the one rib, as fig. 901.

Fig. 902 shows the centre for a still larger arch, built up and framed, he radii and cross pieces being halved or dovetailed together, and to the ribs, as shown.

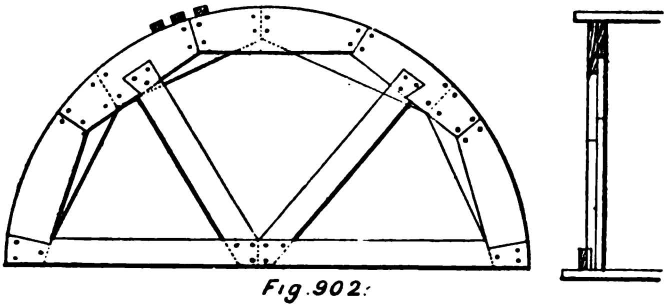


Fig. 902.

Fig. 903 is a sketch of a framed centre, as seen from a point of view above it.

Foundations.—Foundations, as a rule, should be 3 feet below the general surface of the ground—*i.e.*, the trench excavated to receive the bottom of the concrete, or brick footing, should be 3 feet deep, especially

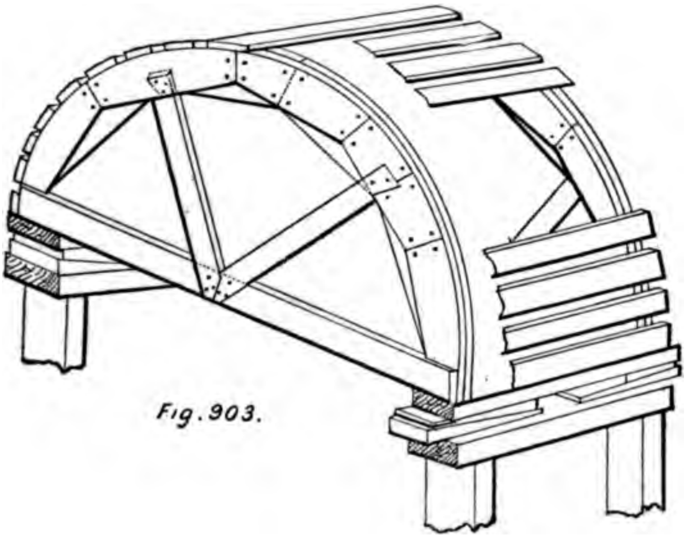


Fig. 903.

in clayey ground, which is liable to be affected by both heat and rain, the former in particular causing it to crack to a depth even exceeding 3 feet. Of course it will be understood that the nature of the ground varies enormously in different parts of the country, sometimes in different parts of the same town, and even, in some cases, in different streets or gardens, two soils differing in nature often being closely adjacent.

A *good* foundation should be in solid as opposed to *made-up* ground; it should be incompressible, and of the same nature throughout, the strata being at right angles to the weight they have to carry—*i.e.*, horizontal, instead of dipping or sloping. When punned with a rammer it should sound "solid," a hollow sound indicating an inferior nature below; and it should resist the pick or crossbar well when driven in, without disintegration of the surrounding mass.

All foundations, of whatever kind, should be made perfectly level (except where they are *stepped*) before they receive the concrete or footings, ground of a stony or rocky nature being levelled with the pick, and the softer kinds well rammed. The solid ground should always be reached; and if there are great variations, etc., arches should be thrown over weak places, when at a great depth, from piers built on the solid. If a solid stratum be reached, with an inferior one below, it is unadvisable to go any deeper, if that solid stratum is sufficiently strong to carry the weight required.

Where the nature of the ground will not allow of the building being built on it with safety, concrete, of specified and adequate depth and strength, is employed in the trench to assist the natural ground by distributing the weight.

Different Soils.—In dealing with the following different kinds of ground, it must be understood that the remarks are made in a general sense, and are not intended to lay down any hard-and-fast rule, as in all cases personal inspection of the site is absolutely necessary before deciding on any points with regard to foundation work.

Solid rock in foundations cannot be bettered when it is sound and alike all over, so that it would be ridiculous to take it out merely to replace it by an inferior article such as concrete. However, the bottom should be made truly level; or, if it is uneven by nature, the loose inferior portions should be taken out, and those places arched over to and from the solid, or concrete should be put in, *lapping* at the joints.

Gravel is the next best and most suitable soil for a sound foundation; and where it is sound it cannot be improved upon, though when it is loose and coarse it should be grouted with lias lime or cement-mortar of required strength, according to circumstances, or otherwise a thin bed of concrete may be put in the trench on the top of the gravel.

Foundations of loose gravel, however, are apt to slip, and consequently the sides must be shored by one or other of the following methods: In tolerably good ground *poling boards*, in size about 9 × 2 inches or 9 × 3 inches, are placed at intervals, in pairs, on each side of the trench, and strutted apart by stout members, small pieces of scaffold poles, from inches in diameter (as fig. 904), being generally sufficient for the . But where the ground is looser the poling boards must be close together, perpendicularly, with *walings*, which are placed

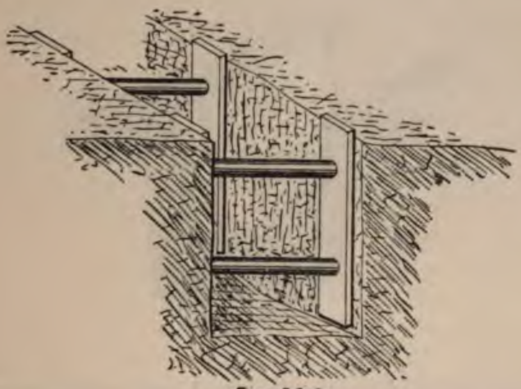


Fig. 904.

ally inside them, and strutted from one to the other, at intervals y 2 to 4 feet, as fig. 905; the poling boards, in this case, varying to 3 inches thick, and the walings being usually 11 × 3 inches.

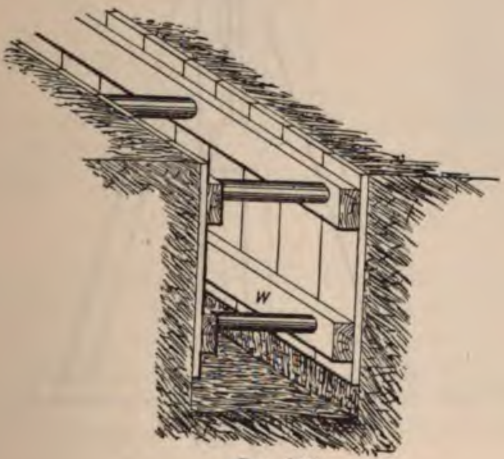


Fig. 905

unning sand it will be obvious that it is impossible to wait until ent depth has been dug out to allow of vertical poling boards being thout the sides previously slipping in; wherefore *sheeting*, as shown in fig. 906, is used, laid longitudinally, and secured by poling boards and strutted, as in the first instance (fig. 904).

Reverting to the consideration of the various natural grounds, the next in order as a substantial formation is a good hard, *sound clay*, which should lie in horizontal strata, as a dipping clay is apt to slip downwards and cause settlements. It is necessary that clay should be well drained, so that the rain shall not have time to affect it so much as to cause any considerable alteration; and the bottom of the concrete, or top of the clay, should be at such a depth as to be beyond the influence of heat, as it is well known that the sun is very apt to cause deep and frequent cracks in clayey ground.

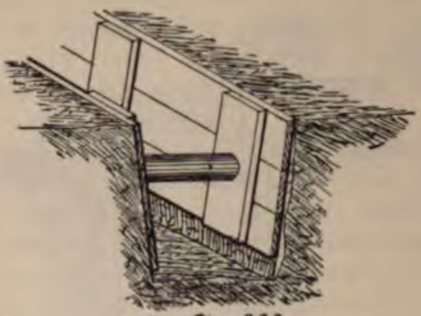
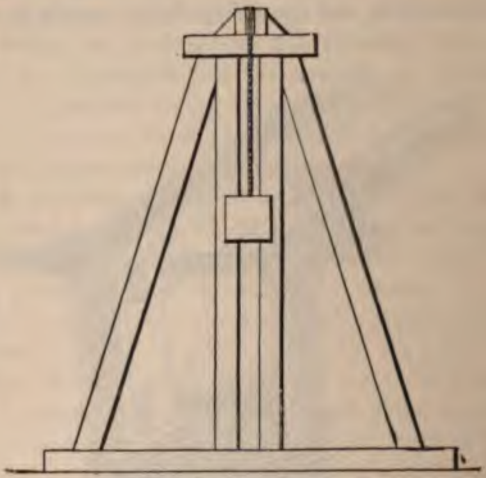


Fig 906.

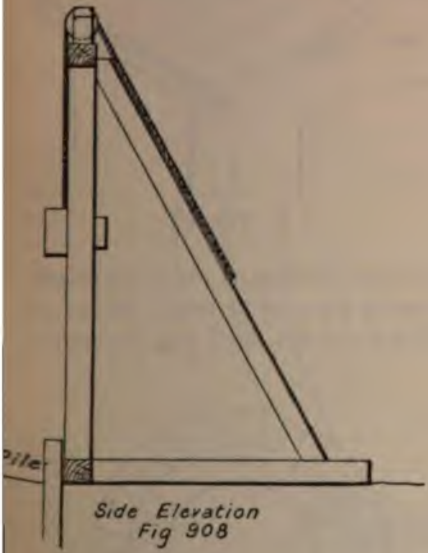


Front Elevation
Fig 907

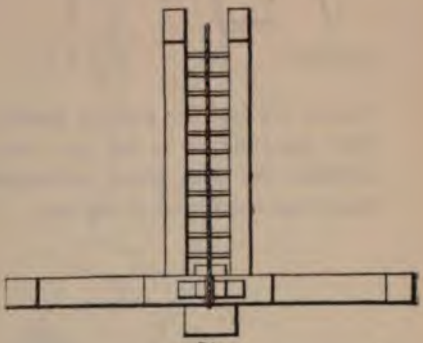
Excavations in hard clays do not always require shoring, though it is advisable to adopt that precaution in the case of the weaker kinds of clay.

Chalk, from its nature, is a very uncertain foundation; though the harder and better qualities may sometimes be as good as rock, while the softer kinds are always very bad, and liable to be greatly affected by wet.

Sand, in whatever form, and especially quicksand, is a most treacherous soil for foundations, having no power to keep itself together, as it were, so that it must not be taken into any account. The best course is to remove it by excavation, if practicable, and replace it with a layer of concrete. Where such sand and other boggy and soft soils are present and of considerable depth, so that the bottom thereof cannot be reached without too much trouble and expense, for their removal, as ought to be done, platforms of wood or *fascines* are adopted and made to carry the whole building, floating, as it were, on the top of the sand; while, in the better qualities of this loose ground, *piles* of square timber of considerable length are driven down to a solid foundation.



Side Elevation
Fig 908



Plan
Fig. 909

This is effected by means of heavy weights, called *monkeys* or *rams*, being directed on to their top by guides held up by framing, as shown in figs. 907, 908, and 909, the weights being elevated by hand or by suitable machinery to a certain adequate height, and then allowed to fall on the head of the pile, which is encircled by a wrought iron ring to prevent it from splitting under the force of the impact; while the bottom or point of the pile is shod with an iron-pointed shoe, as fig. 910.

These piles are from 9 to 12 inches square, and spaced at from 1 to 3 or 4 feet apart in each direction, as shown in fig. 911, being driven firmly into the solid ground, while their heads are connected by bearers of timber of various sizes into which they are tenoned, and on these bearers are laid the wooden planks or stone slabbing on which the foundations are built, as in fig. 912; the spaces for a short depth, below and between the piles, being occasionally dug out and filled with concrete to make one solid mass at the top.

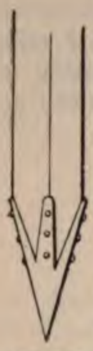
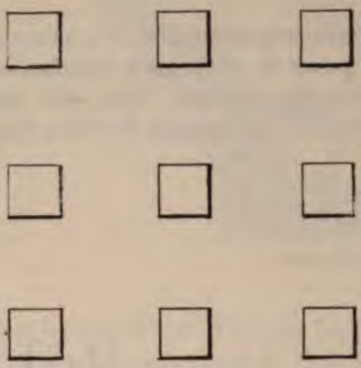


Fig 910.



Plan
Fig 911.

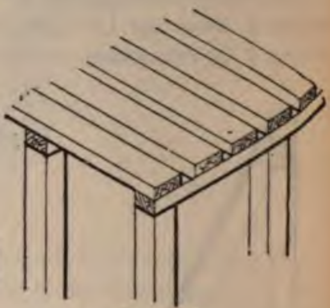


Fig.912

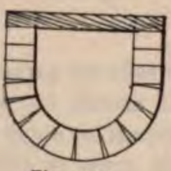


Fig 913

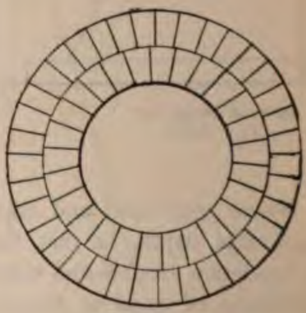


Fig 914

The use of inverted arches for the distribution of the weight in variable foundations has been dealt with in Chapter III., to which the student is referred.

Sewers.—*Sewers* are large drains, which are of a size beyond the limit of the use of glazed or other piping for the purpose, built of brick, and circular, oval, or egg-shaped in section. It should be pointed out that lazed stoneware pipes are now made in sizes up to 3 feet in diameter, o that brick sewers, on account of their awkwardness, would not be built f any sizes below this limit, to supersede piping.

Therefore, the first kind of brick sewer in general use is what is alled a *culvert drain*, the straight sides and circular bottom being built of rickwork, either 4½ or 9 inches thick, and covered over with stone slabs, s fig. 913; or the sewer is built quite circular with special bricks, as fig. 14; though this is the more awkward method of the two.

Where sewers, built on the above lines, are of such large dimensions hat true circles would take up too much room, and render them nearly

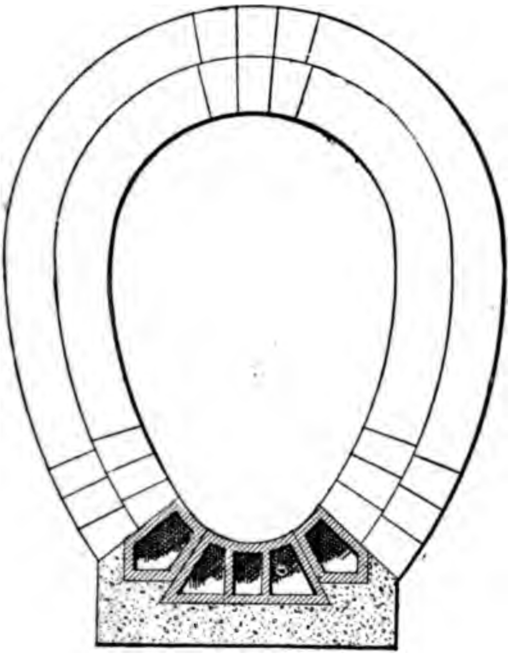
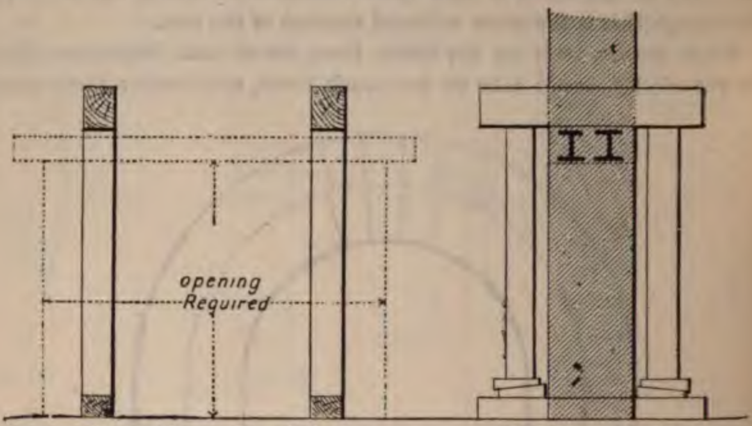


Fig. 915.

lat where a good curve to the invert is required for the quick flow of ewage, they are built egg-shaped, as fig. 915; from which it will be seen hat the sewage, whether its volume be great or small, has the best and most equal chance of the necessary quick flow in this form, whereas in the circular kind this cannot be the case. As a rule, the bottoms, r *invert* blocks, should not be of more than 9 inches radius (the maller the better, within reason), and of glazed stoneware. The general roportion for the widths and heights is that the diameter of the top circle s double that of the bottom or invert, and the internal height from bottom to top three times that diameter, the remaining space between the circles at the side walls being lined in with arcs tangential to both circles.

Shoring and Strutting.—*Shoring*, as applied to excavations, has been dealt with previously; and it is now proposed to give the student an idea of shoring to buildings which require additional support, when the adjoining or part of their own property has been pulled down.



Elevation: Fig. 916 Section: Fig. 917.

In cases where large openings are to be cut into main walls it is necessary that the part above must be shored while the girders to carry it are being put in. This is done by means of struts, posts, or legs, raised perpendicularly from the balk-sills on the solid ground or floor *made solid*, and supporting needles going through holes cut above the height of the opening required, as figs. 916 and 917, the whole being tightened

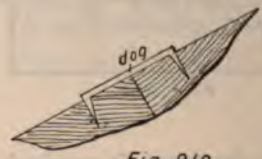


Fig 918

up by wedges, at the feet of the posts, as shown on the side elevation. The dotted lines show the proposed position of the girders and the opening to be cut in the wall after the weight above has been secured by the shoring, which is generally constructed of balk-timber 10 or 12 inches square, as required.

The joints, as in all strutting or shoring, are either bolted together or secured by wrought iron *dogs*, as fig. 918, driven home into each member.

ne house between two others has been pulled down (which is usual occurrence) a temporary timber framing, consisting of sses, is built between the two from wall to wall, to allow each e other, as it were. These forms of course vary infinitely, and ing strengths, according to the spans and distances apart, if the he opening requires more than one set of framing. A long aced vertically up the walls of each house, and the framing is d wedged tight between them, as fig. 919; or where one house

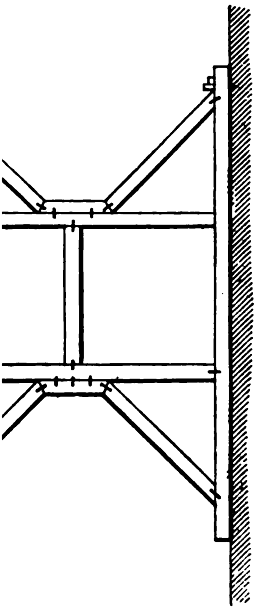


Fig. 919.

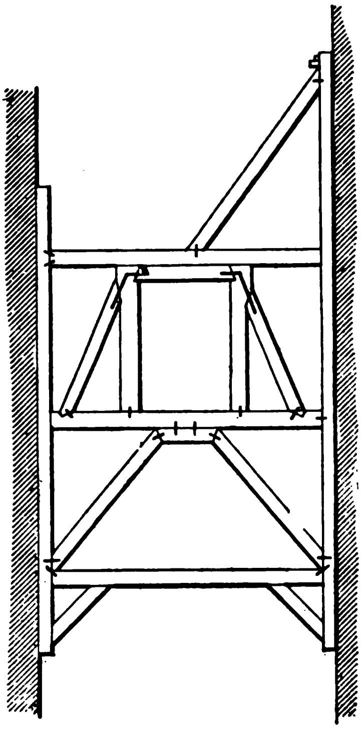


Fig. 920.

an the other, and the width requires a truss similar to king or ts in roofs, they are treated as in fig. 920, though the work can various other manners, and different men have different ideas ject.

of buildings which require to be strutted, and end houses which strutted from another building, are dealt with by means of *es*, as fig. 921, with long timbers, or as in fig. 922, with short cured by boards nailed on each side, and bound together with The butting pieces in the ground, backed up by the vertical post solidly driven into the ground, should incline at right angles to the pressure of the chief shore or strut. Each of the shores is secured at the top, as in fig. 923, a hole being cut into the upright plank and wall, into which the *pin* or *needle* is driven. This pin is assisted by a cleat nailed above it, and the shore is butted up and wedged against it, as shown.

Scaffolding.—*Scaffolding*, as familiar to everybody, is a series of temporary platforms, raised up, as the building increases in height, to allow the men to work from them at various stages, and store their materials for immediate use. They consist of poles, ledgers, putlogs, boards, cords, and wedges, the poles being the upright circular members, secured in the ground about 9 feet apart, as A, on figs. 923 and 924. The ledgers, B, running longitudinally at every different rise of 4 or 5 feet, are secured by the cords 18 feet long, bound tightly round the two and wedged up. From the ledgers to and into holes in the wall (which is about 5 feet away) the putlogs C are laid every few feet to receive the boards D, which form the platform. When the framing is of any height it is braced, as shown by the ordinary scaffold poles, secured by the cords, and wedged like the ledgers.

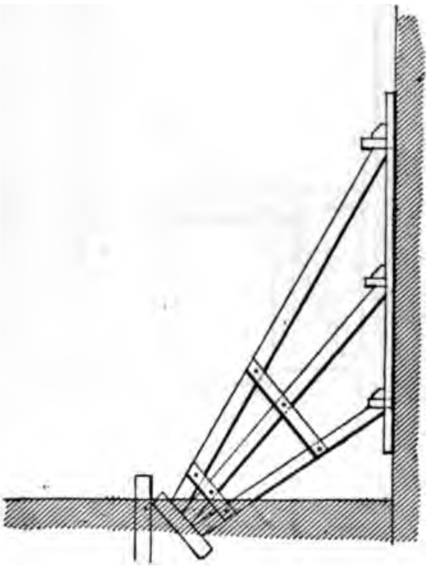


Fig. 921.

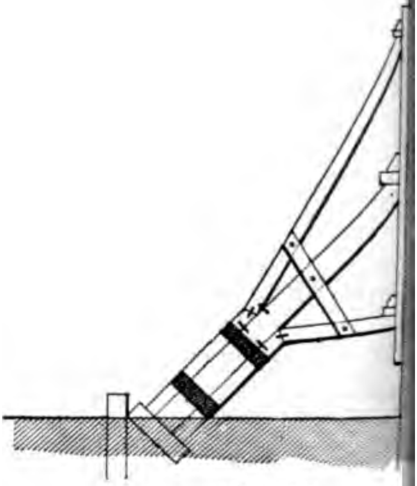


Fig. 922.

Masonry requires stronger scaffolding, which is, therefore, usually strengthened for the purpose by the use of 3-inch battens, instead of 1½-inch planks, to form the platform; and also it will not allow of putlogs

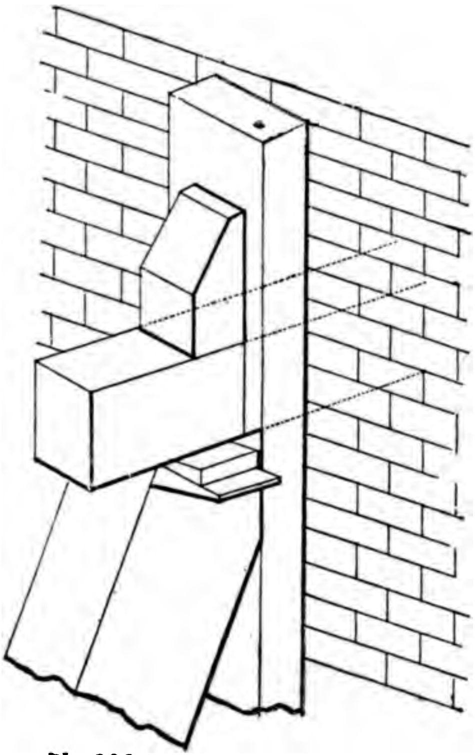
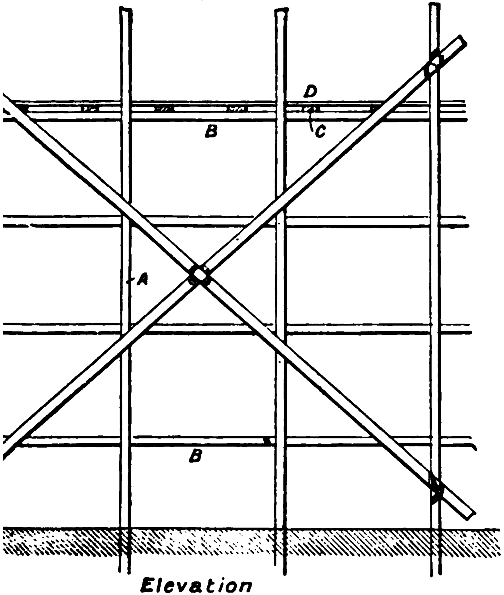
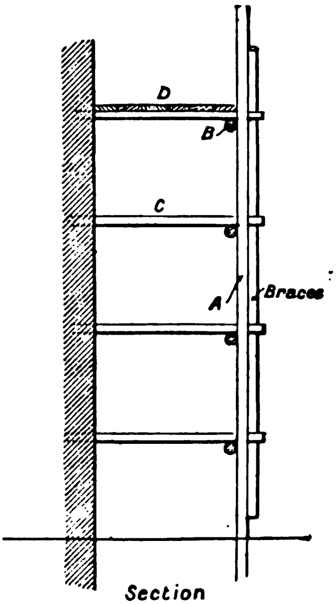


Fig. 923.



Elevation
Fig 923



Section
Fig 924

going into the walls, in which case they are strutted up from one platform, or height, or putlog, to the other, by planks placed against the wall.

In Scotland the work is built from the inside, the working platforms being raised from floor to floor as the work proceeds.

Gabers scaffolds are little used, so it is unnecessary to enter into particulars about them, more than to say that the standards, putlogs, etc., are made by bolting deals together, the whole being cross-braced, and bolted to the standards and to one another, presenting an appearance like a quarry floor laid diagonally.

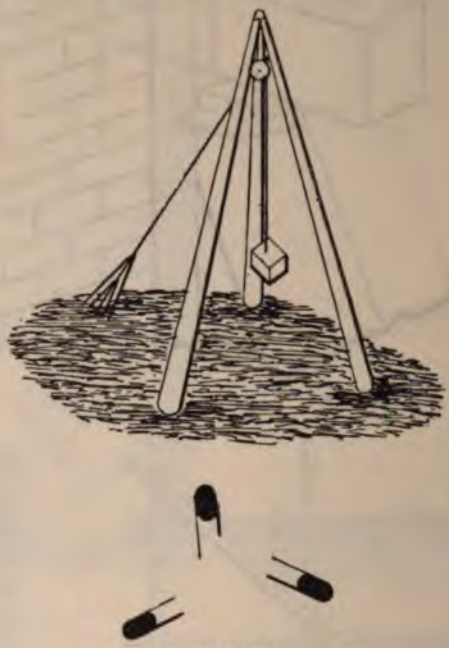


Fig. 925.

Hoisting Tackle.—*Stones* are lifted and set into position in the work by means of ropes and pulleys supported by *shear-legs* (as fig. 925), which are scaffold poles let into or bedded in the ground securely; or the pulleys are secured to the apex of two poles held in position by guy ropes, as fig. 926; and when the work gets beyond the use of these methods, above the ground, derrick cranes are employed to hoist up all materials and to bed stones, though they are often used on the ground floor in place of shear legs or guy ropes and poles. They consist of two legs, from platforms or beds, fixed on the various floors sufficiently weighted to prevent any slipping out, inclining up to an apex to which an upright is raised from another platform immediately under the apex, on which also

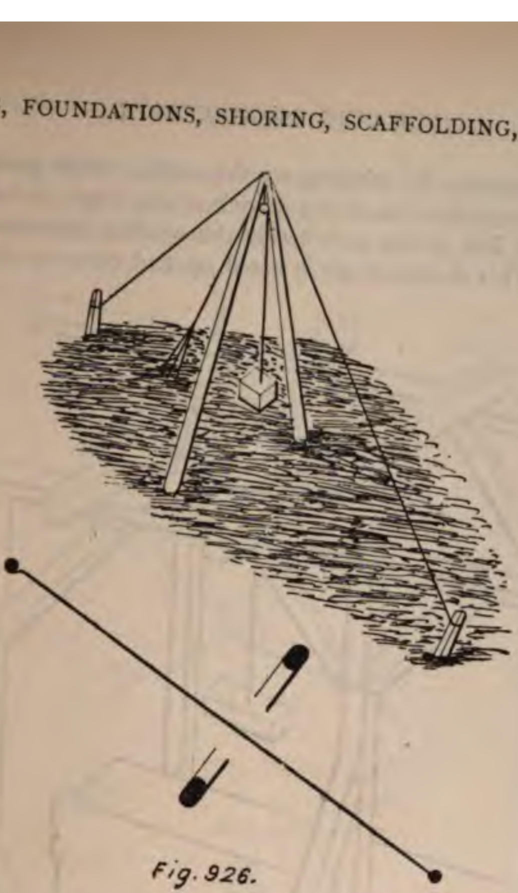


Fig. 926.

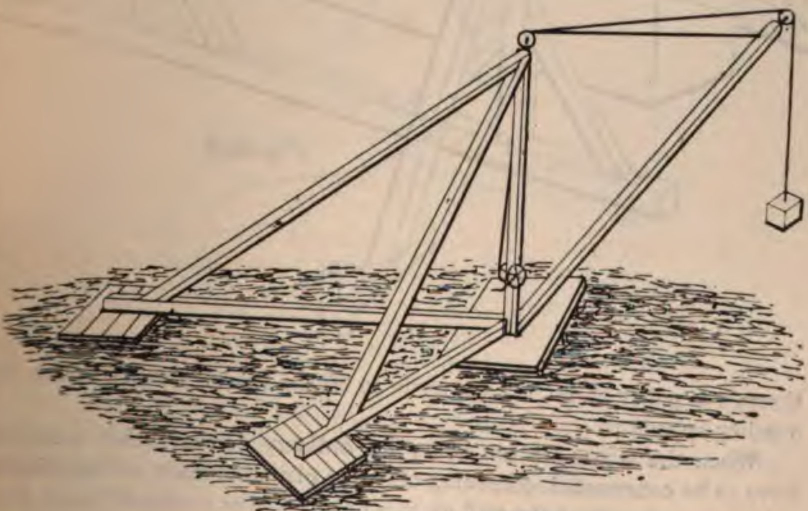


Fig. 927.

stands the apparatus for winding up the chain, which goes up to the apex and thence to the end of the derrick or gib, which is hinged at the bottom of the foot of the post beside the winding apparatus, as shown in fig. 927. This derrick or gib is raised up and down as required, and, through a pulley at its top, the chain to lift the stones s worked from the winding apparatus.

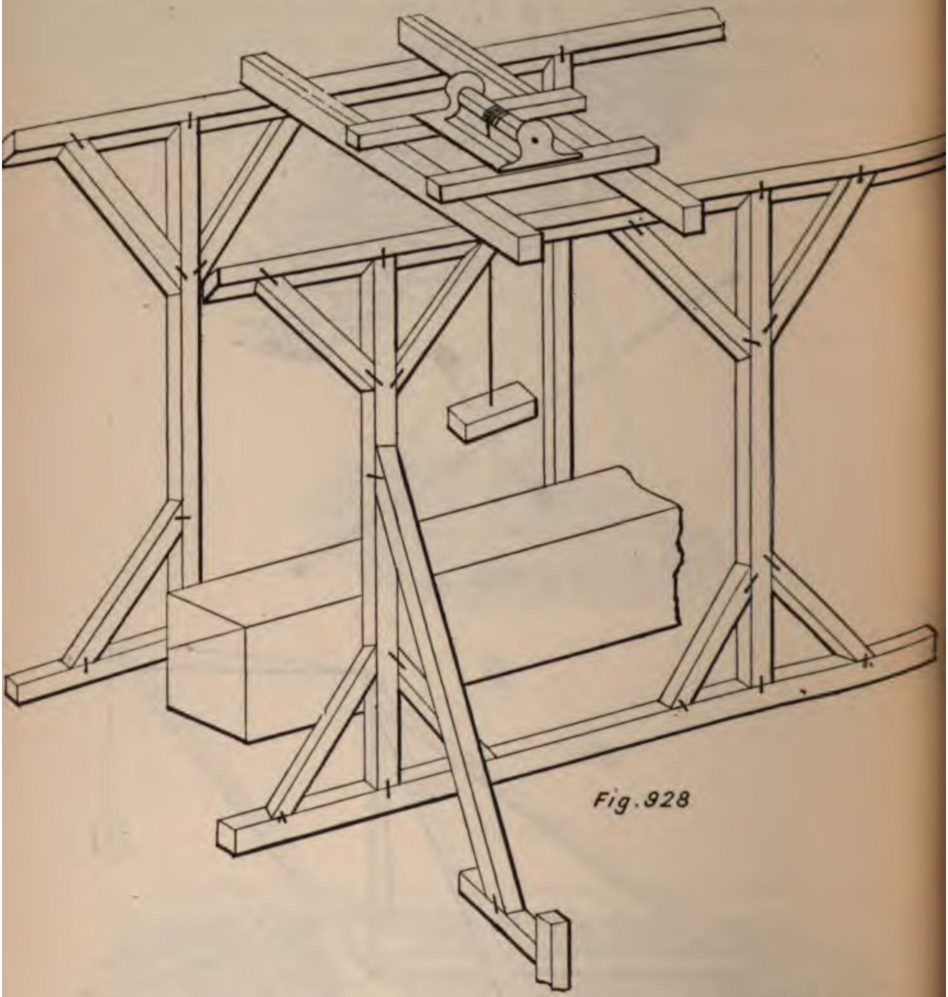


Fig. 928

When the stones are too heavy for ordinary derrick cranes travellers have to be constructed, consisting of strong platforms made of balk-timber raised on each side of the wall up to a height so that a trussed beam from one to the otber can work or travel along above the required height of the wall. These trussed beams—for they are in pairs—run on wheels on rails fixed on the upper face of the top beams of the framing on each side; and they support the jenny or crab which runs across, from side to side, on wheels guided by rails on the trussed beams.

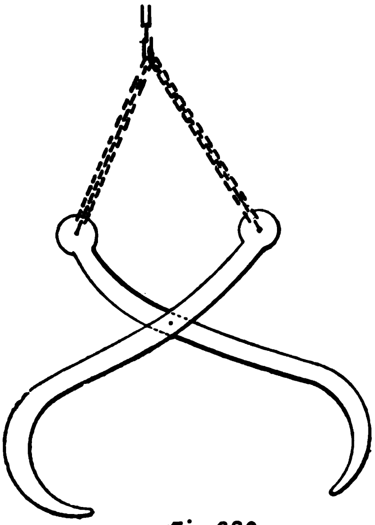


Fig. 929.

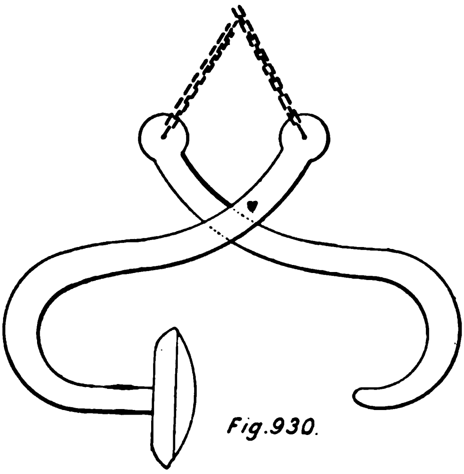


Fig. 930.

The jenny is used for hoisting the stones, and can be moved to any position along the traveller beams, which in themselves can be worked along the side framing, as the sketch will indicate (see fig. 928).

The stones lifted by either of the above methods are grasped by nippers, as fig. 929; and also with a round block, as fig. 930, on one side, whenever the face might be injured by the nippers tightening when the weight hangs on them.

Another method is to cut a mortise in the top bed of the stone, and insert a *Lewis*, as fig. 931, which, it will be seen, is dovetailed in, and secured to the chain or rope.

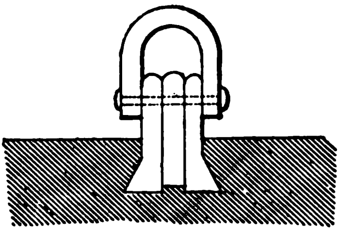


Fig. 931.

Underpinning is the building of walls underneath an existing wall, or structure, such as cellar-walls below a building where there has been no cellar previously. These works require great care, so that settlements or the collapse of the building are guarded against; and with this view all underpinning should be done in cement-mortar, and in very short lengths, 2 or 3 lineal feet only of excavation being taken out at a time, and the work built up and wedged tightly and completely to the existing wall above before any more earth is taken out from under the wall further on.

CHAPTER XXIII.

MISCELLANEOUS MATERIALS.

Asphalte—Granite—Limes and Cements—Mortar—Concrete—Marble—Terra-cotta—Artificial Stones.

It is proposed in this chapter to deal with certain building materials which have not been treated of in (as it were) their proper places, in reference to their application and use.

Asphalte.—*Asphalte* is a limestone saturated with naphtha, found in a natural state on the Continent at places enumerated below. It can also be made artificially by a combination of bitumen (in the form of *pitch*) with other solid matter. The natural asphalte is generally ground and run into moulds, with sand and a little pitch (when it is called mastic), and sold in small blocks containing a little more than a cubic foot. It is made fit for use by being melted in a furnace and applied on the walls while hot; and as it has the qualities of being frost-proof, damp-proof, and fire-proof (up to a certain degree), it can be used for damp courses, for protecting damp walls, covering roofs, and for baths, skirtings, and street paving. It should be laid by experienced workmen, in layers from ¾ to 1 inch thick, and rubbed to a smooth surface, on a suitable bed of concrete, also floated to a smooth level top, as a foundation for the work.

Of the various kinds of asphalte in the market the following are the chief:—

Limmer, found near Hanover in a natural state, and used for general purposes in the usual way.

Seyssel, or Claridge's asphalte, as it is called, is found in the Jura mountains, near Pyrmont-Seyssel, on the eastern frontier of France, in a rocky state, containing about 90 per cent. of carbonate of lime and 10 per cent. of bitumen. There are three qualities of it—the fine, fine-gritted, and coarse-gritted—used for the different kinds of work previously enumerated.

Val-de-Travers asphalte is found near Neufchatel, in Switzerland, in a rock containing from 12 to 20 per cent. of bitumen, which renders it a first-class asphalte, and suitable for the best work.

Asphalte damp courses are often made by mixtures containing coal-tar pitch and real pitch, in the original natural form of bitumen, the material which makes the limestone rock asphaltic, and which is found in its pure state in Palestine, near the Dead Sea, and also in the island of Trinidad.

Granite.—*Granite* is an igneous rock, containing quartz, feldspar, and mica, usually in the proportions of about 5, 4, and 1 respectively. Found in Scotland at Peterhead and Aberdeen, in Aberdeenshire, and in Kirkcudbrightshire; while in England it is found at Mount Sorrel, in Leicestershire, and several places in Devon and Cornwall.

The quality of the granite depends on the quartz, both for hardness and durability, while the feldspar gives it its colour, and has a great effect on its weathering properties, bad feldspar causing the disintegration of the mass. The mica, though in small quantity, is a source of weakness, and must not be taken into account, except when there is too much of it.

Granite is quarried by blasting and wedging; it is dressed in the quarry, because it is so hard when it loses its sap, and it is capable of taking a high degree of polish. It is used chiefly for ornamental purposes in the building trade, principally for shafts or columns and bases to large buildings. The Leicestershire granite is of a pink colour; the Devon and Cornwall varieties are chiefly grey; and the Scotch kinds either red or grey; while Syenite, or Syenitic granite (found in Egypt, and containing hornblende instead of mica in the first instance, and, in addition to the quartz, feldspar and mica), is darker in colour owing to the hornblende, and tougher than the British varieties.

Lime and Cements are the products of limestones of various composition, burnt in kilns by calcination, as it is called.

Lime.—Pure lime, in itself, has neither power of setting nor ultimate strength, and it is only when combined with clay and burnt that it is of value as a building material. The presence of clay, up to a certain percentage, regulates the value of its strength and setting power, a pure, rich, or *fat* lime (as explained and used for plastering) containing little or no clay, which allows it to slake at once with a loud crackling noise and considerable steam. It is only fit for plastering and other sanitary purposes, and can be made out of most pure limestones, including the Bath and Portland varieties, marble, and chalk.

Poor lime is the next degree, containing from 80 to 90 per cent. of carbonate of lime, with a residue of sand, and other qualities which give it no hydraulic properties, as its power of setting under damp conditions and in water is called. It may be termed a useless variety as compared with the others, considering that it slakes sluggishly and imperfectly, which makes it valueless for plastering; while for mortar it is worse than "fat" lime, because it will neither increase so much by slaking, nor take such a quantity of sand, being neither one thing nor the other. Rich and poor limes never set hard, though sometimes they may harden a little on the exterior only.

The first best, as a good, quick-setting, and strong lime, is called a *feebly hydraulic* lime, containing 80 to 90 per cent. of carbonate of lime and 8 or 10 per cent. of clay, which are the required ingredients. The small amount in which it is present in this kind is not as much as is wanted, though its slaking may be considerably reduced. The clay is required to such an extent that its silica and alumina will take up in combination most of the lime, forming silicates and aluminates of lime, the former being formed at an early stage of the burning, and the latter after subjection to a considerable degree of heat; and it is this fact which makes it necessary that the stronger limes and cements should be the more burnt.

This combination reaches its state of perfection (as about to be explained), and then it declines in efficiency and value, owing to the presence of too much clay.

Hydraulic limes, the fourth class, contain from 15 to 20 per cent. of clay, which takes some time before it begins to slake, and then only in a small degree. It sets in about a week, and is fairly strong. It is the product of grey chalk, found in Sussex and Surrey.

An *eminently hydraulic* lime contains from 20 to 30 per cent. of clay, is of a greenish-yellow colour, found in the lias lime formations at Barrow-on-Soar, in Leicestershire; Rugby and Stockton, in Warwickshire; Whitby, in Yorkshire; Lyme Regis, in Dorset; and Holywell, in Wales. It sets hard and quickly, and is very difficult to slake.

When the clay is mixed with the lime in a natural state, or otherwise artificially in the proportion of 1 and 2, the resulting combination of chemicals obtained at a great heat is called a *cement*, the Portland variety being the best, of which there are two different kinds, slow and quick setting—the former being heavy and the latter light in weight.

Cement.—Generally speaking, cement is made from cement-stones or pebbles, containing from 30 to 35 per cent. of clay, which proportion is the best for the complete combination of the different constituents, as previously pointed out.

This natural cement is made chiefly at Rugby and Stockton, in Warwickshire, and in Kent; while artificial varieties are made in different parts of the country (principally in the south) from a mixture of white chalk and unburnt clay, in the proportion of about 2 to 1, which is calcined at a very high temperature to produce a heavy, slow-setting cement.

Good cement should be of a very fine powder, leaving no more than 10 per cent. residue when sifted through a sieve of 2,500 meshes per square inch. It should be clean and cool to the arm when thrust into it, and it may be either quick or slow-setting—the slower it is the stronger it ultimately becomes, weighing up to 120 lbs. per striked bushel; while the quick-setting quality weighs from 95 lbs. to 112 lbs. per bushel. It is capable of bearing a tensile strain of 350 lbs. per inch superficial, and is of a greenish-grey colour; a brown tint indicating excess of clay, and blue excess of lime. It should be stored on wooden floors in dry sheds.

Roman cement contains too much clay (from 30 to 45 per cent.), producing a brown quick-setting material, weighing no more than 75 lbs. per striked bushel, and of little ultimate strength compared with Portland. It is useful, however, in work which has to be done quickly, such as sea-walls, etc., requiring that the work should set in the interval between tides.

Selenitic is a patent artificial cement, made from lias lime, by the admixture of plaster-of-Paris or a sulphate of lime, which stops all slaking, and makes the cement set quicker, with a greater proportion of sand, without apparent loss of strength.

Pure and poor limes are sold in lumps by the ton; lias limes in lumps or in bags, when ground for concrete purposes; while cements are sold either in bags or casks.

Burning Lime, of whatever quality of the stone or lias kinds, is burnt in clamps or kilns of both Tunnel and Flare varieties, on both the intermittent and continuous systems; while cements are burnt in conically shaped, brick-lined kilns, as they require much more heat.

Clamps are very little used, as they are a poor and expensive way of working; the lime and fuel being placed in the clamps in alternate layers, and covered over with some material to keep in the heat.

Tunnel kilns are of different sections, on the continuous principle; the lime and coal being added from time to time through an orifice at the top, heated gradually, and abstracted, as it gets down in parts, from a hole at the bottom and away from the fire; while *flare* kilns are on the intermittent system, the usual cylindrical brick-lined spaces being filled with lime and fuel, and burnt all together, emptied, and then refilled.

Mortar is a mixture of sand with lime or cement in various proportions, according to requirements, to bind together the solid materials used in a building.

Limes should be first thoroughly slaked, and then mixed in a mortar mill with certain proportions of sand, ashes, brick, or stone dust, etc., being thoroughly ground and amalgamated together. When mixed by hand care should be taken that the lime and sand are screened, in order to separate all large lumps, etc., before the water is added to make it into the creamy mass required, no more being mixed under any circumstances than is required for the day's consumption.

Cement is generally mixed, by hand, with very clean, sharp sand-ı must be washed if necessary, though, on large buildings, xed by machinery; and although lime-mortar made by hand hat made by machinery, cement-mortar is not affected either he other, on account of its fineness of grit and freedom

proportion for ordinary work, under no special circumstances,

Pure lime . .	1 part to 3 parts of sand.
c lime . . .	1 „ 2 to 3 parts of sand.
cement . . .	1 „ 3 to 5 „ „
„ . . .	1 „ 1 part of sand.
„ . . .	1 „ 4 to 6 parts of sand.

.—*Concrete* is a mixture of gravel, broken stone, slag, or *agglomerate* or *aggregate*, with either ground lias lime, Selenitic cements, known as the *matrix* when mixed with used in bad or uncertain soils to form a sound foundation structure, also for fireproof arches, and coverings to the floors, to keep out damp and receive layers of hard floors.

ırtions in which the agglomerate and matrix are mixed vary according to the weight of the proposed superincumbent materials of which it is made. The usual admixtures are: : lias lime to from 3 to 5 parts of ballast or agglomerate, ıd, gravel, slag, brickbats, etc.; 1 part of Portland cement to ballast, etc.; or 1 part of Selenitic cement to from 6 to 8

ĸ, consisting of the sand and cement, or lime, is often mixed first, and then poured on to the agglomerate on a wooden which the whole is turned over and thoroughly incorporated. : lime or cement is thoroughly mixed with the agglomerate er which the water is added, and it is again turned over for the second mixing.

ıg being done, the resulting concrete is either wheeled and ıe trenches from a height, or laid in gently from buckets, the process being followed by careful ramming together and

stones should be allowed in the agglomerate or aggregate. crete foundations should be small enough to pass through a in diameter; while those for arches, lintels, and other special s through a ring 1½ inches in diameter.

-*Marbles* are pure limestones, of very hard and compact ıg in colour, and capable of taking a high polish. They are onshire, Dorsetshire, Scotland, and Ireland; while considerable quantities come from the continent of Europe, and elsewhere. As a building material marble is chiefly used for ornamental purposes, in internal work only, such as columns, staircases, chimneypieces, and the like.

Serpentine is a similar kind of material, used for similar purposes, but much softer in its nature, though compact, and capable of receiving a first-class polish. It is of various colours, in streaky forms, from which it derives its name; and it belongs to the igneous rock formation, partaking of the nature of a granite or porphyry, and is found near the Lizard, on the south coast of England. When free from white streaks it is suitable for external ornament, though better adapted for internal work.

Trap or Whinstone is a hard mixture of feldspar and hornblende, of a crystalline nature, very tough, and of a green or black colour, used for setts, paving, road-metal, etc. The best quality is found in Northumberland; at Penmaenmawr, in Wales; and in Scotland.

Terra-cotta.—Terra-cotta, a substitute for stone, for dressings to buildings, is the product of a rich clay found in several parts of the country, especially at Ruabon, Rowley Regis, and Tamworth. It is made by mixing several kinds of clays with ground glass or pottery to prevent shrinkage. The mass is ground to a powder, mixed in water, finely strained, kneaded, and then cast into moulds of the required patterns, etc., then dried and baked in domed kilns, at a very high temperature, and gradually cooled.

It may be either of a rich red, pink, or buff colour, according to the presence of iron, the light varieties indicating insufficient burning, and a green tint a bad material, which will be very absorbent. The blocks in which terra-cotta is made are cast hollow, soaked in water, and filled in with fine concrete before being set in position in a similar manner to stonework. Terra-cotta has the advantages of great durability and hardness, combined with cheapness and light weight; but against these must be set the fact that the unequal shrinkage, caused in the burning by the nature of the mixture, is apt to prevent the work, especially mouldings, carrying good lines.

Artificial Stones are made, generally speaking, of finely ground stone, ballast, and sand, mixed with Portland cement or other setting materials.

Victoria or *silicated* stone consists of granite dust and Portland cement, mixed to a paste, cast into moulds, dried and immersed in a silicate of an alkali to give it a hard, durable, and stronger weathering face. It is principally used for pavings, as a substitute for the Yorkshire stones, for sills, copings, landings, steps, etc., because it is a cheaper article.

Apoenite and *Ransome's Patent Stone* are similar materials; the former being made, in the first instance, from a mixture of sand, silicate, and Portland cement, while "Ransome's" variety is made from sand, silicate, and chalk, mixed to a paste, cast into moulds, and immersed in chloride of calcium.

h kinds are greatly used for steps, landings, pavings, and all other poses where natural stones are used. They have the advantages of ng cheap, requiring little labour, are non-absorbent, of great tensile and npressive strength, and light weight.

Peters' Patent Artificial Sandstone can be made of any colour and of in according to the sand used in its preparation. It can be made in district, and not necessarily at the manufactory, the quality and ength of the stone as at present ascertained being everything that can desired.

Pozzuolana is a substitute for sand, of a clayey and ashy nature, nd in Italy, in the neighbourhood of volcanoes, and is mixed with lime make mortars and water cements.

CHAPTER XXIV.

STRESSES.

Definitions—Loads—Stresses—Reactions—Discernment of Strains.

It is only proposed, in this chapter (which is a preliminary to Chapter XXV., where the subject is more fully discussed), to deal with the above subject as far as the syllabus of the advanced course requires the student to go in that stage; and, as a necessary preliminary, an explanation will first be given of the general terms in use.

Definitions.—Different kinds of loads cause different stresses on structures, producing different strains, which the principle of equilibrium demands shall be met by reactions of corresponding power, to resist those actions successfully. The stress is the power of the load.

Thus, one man may push another against a wall with such force (equivalent to a load) as to cause a compressive stress, acting in a manner likely to crush him, unless he can call forth a reaction on his own part to resist the strain which that stress or action of pushing puts on his strength, and to prevent his being crushed against the wall.

Or, a team of men in a tug of war, by pulling, cause a tensile stress, which produces a strain on the other team, who must have the power to resist the strain imposed on them by such stress, or else they will be drawn over the line.

Or, again, the blades of a pair of scissors meeting, with a piece of material between them, cause a shearing stress, or action tending to shear or cut that material in two, unless it has the nature or power to set in a reaction, tending to resist or counterbalance the strain put upon it by such action or stress.

Having shown the student the *application* of the general terms, an explanation of each one individually, with the various forms it takes, will be given in detail.

Loads.—*A load* is the weight or power of the external forces acting on a certain structure, together with the weight of the structure itself; and ay be either a live or a dead load, the whole of which is either entrated at any one point, or at any number of points on the ture, or it is distributed equally over the whole, or any part, of same.

A live load is a moving force applied suddenly and intermittently, mpanied by shocks and vibrations; such as a train going over a ge, a sudden gust of wind on a roof, or a weight falling suddenly on am or floor; while

A dead load consists of a force or weight of a continuous nature, lied gradually and remaining; such as solid independent and unsup-ting walls on breastsummers, materials stored on warehouse floors, etc.

It has been proved that live loads produce twice as great strains as d loads of equal weight or force; therefore structures will carry twice nuch dead load as live load.

A breaking load is that which is so great as to produce fracture to structure, while *a safe or working load* is that which a structure will y with safety and without any apparent risk. A safe or working load, ing a stress, is generally one-fifth of that of the breaking load. The between the two, as one and five in this instance, is called the *or of safety.*

Stresses are the actions or forces which cause the strain, and are of ifferent kinds, including :—

"Compressive," "tensile," "shearing," "transverse," "bearing," and sional" stresses, the latter of which will not be dealt with, as it is not with in buildings.

Compressive stress is that which crushes a thing, causing a strain of pression, especially present in columns and posts of buildings, while struts in roof trusses are generally subject to it.

Tensile stress has a tendency to pull out or tear a material asunder, and et with in all ties and suspenders, in roof trusses, and other framed ctures. A simple method to distinguish between compressive and ile stresses is to consider whether a piece of string or rope, of a ble nature, could be substituted for the member without detriment to structure, neglecting, of course, the amount of the stress. If rope or g would answer the same purpose, it may be regarded as certain that member is in tension; and if not, it may be taken for granted that, rdinary roof-structures, the member is in compression.

Shearing is that stress which shears or cuts the body, and is especially licable to riveted joints, where one plate slips along the other, cutting, hearing in two the rivets which connect them. The web of ordinary ers is subject to shearing, inasmuch as the top flange being in com-sion and the bottom in tension, or *vice versâ*, the two stresses have ndency to draw together like the two blades of a pair of scissors

Transverse stresses are met with in the bearing members of a structure, such as lintels, joists, rafters, and breastsummers, on which the stress has a tendency to bend the member and break it across, if it has not sufficient power in itself to resist the strain put upon it by the action or stress caused by the load.

Bearing stress may be said to be the opposite of shearing, as the action on the plates, caused by the successful resistance of the rivets to being cut in two, results in the rivets cutting into the plates compressing or stretching them (when of insufficient strength), so that the rivet holes are enlarged.

Shearing affects rivets, and *bearing* the plates, in riveted joints.

Reactions.—The principle of equilibrium demands, for the sake of stability, that the strains which these stresses impose upon structures and their different members shall be met by a resistance in the nature and strength of the materials capable of withstanding those strains. Their *actions* must be met by corresponding *reactions*, which are located, as it were, at the points of support.

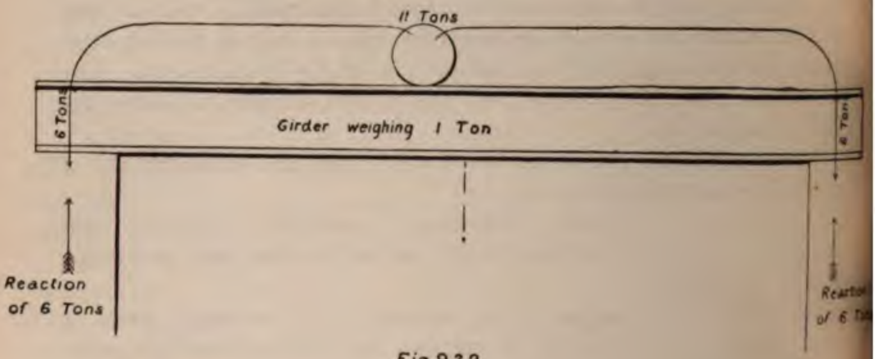


Fig. 932

For instance, a girder, weighing 1 ton, and carrying a load of 11 tons, is supported by two columns, which, it is obvious, must be of sufficient strength to be able to keep up or resist between them the 12 tons of pressure or strain which the stress or action of the load imposes upon them; or, reverting to the "tug of war," the competing teams must be evenly balanced to keep in equilibrium, thus making it clear that actions must be met by reactions of equal or greater strength in order that the latter may succeed or hold their own.

When a girder is uniformly loaded, or carries its load in the centre, it is obvious that each support will carry an equal proportion; therefore the two reactions required to meet the strain on the supports must together be equivalent to the load, and of equal (or greater) power.

Thus, a girder, weighing 1 ton, and carrying 11 tons, either at its centre, as fig. 932, or uniformly distributed over its whole length, as fig. 933 (the total load, or external force, being 12 tons), brings about an action of 6 tons at each support, and each of these has to be met by a reaction of an upward tendency, equivalent (at least) to 6 tons, to prevent the columns being crushed down by those loads.

When these loads, however, are placed in different positions at unequal distances from the supports, it is plain that the stress from the loads acts unequally on the supports; that nearest the load, of course, taking the lion's share.

In such cases the principle employed in ascertaining the amount of strain imposed on each support is that of "proportion," as regulated by the different lengths into which the girder is divided by the load. Thus a girder 20 feet long, with a load of 10 tons 5 feet from one of the supports and 15 feet from the other, would transmit its load to the supports in the proportion of 5 and 15, the one nearest to the load, of course, taking the 15 parts—*i.e.*, three-quarters (as fig. 934). The rule for calculating the reactions required is therefore: "Multiply the load by its distance from the *other* support, and divide by the span," to give the reaction. Thus:—

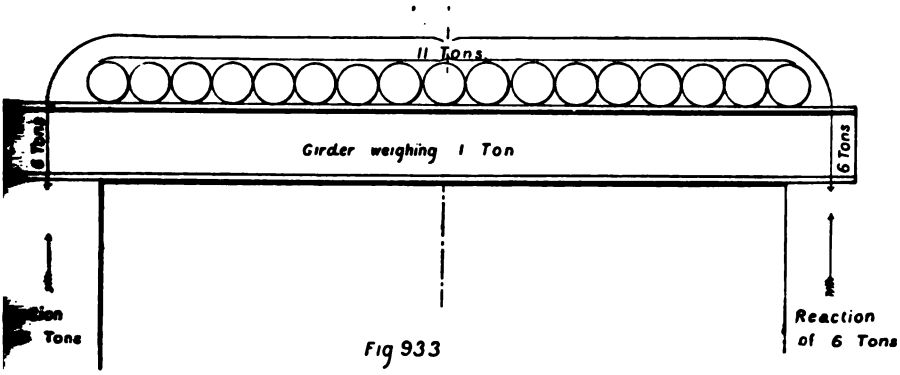


Fig 933

$$\begin{array}{l} \text{Reaction at A} = \overset{\text{tons feet}}{\dfrac{10 \times 5}{20}} = \dfrac{50}{20} = 2\tfrac{1}{4} \text{ tons} \\ \text{Reaction at B} = \dfrac{10 \times 15}{20} = \dfrac{150}{20} = 7\tfrac{1}{4} \text{ ''} \end{array} \Bigg\} = 10 \text{ tons.}$$

The sum of the two reactions, as calculated, should be exactly the same as

When two or more loads are placed on one girder, each load must dealt with separately, as shown below in reference to fig. 935, wh

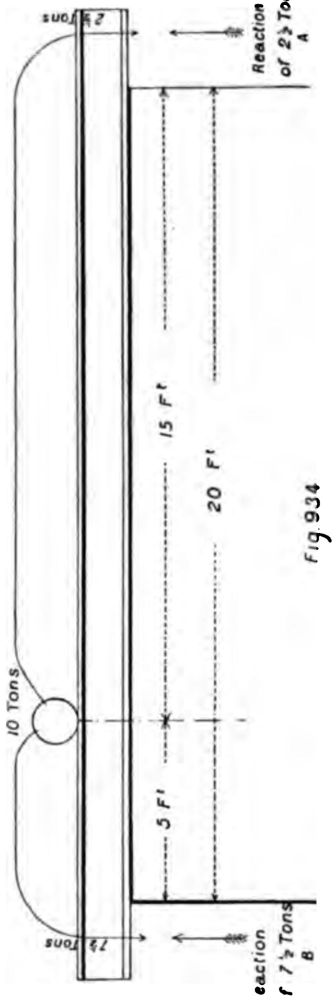


Fig 934

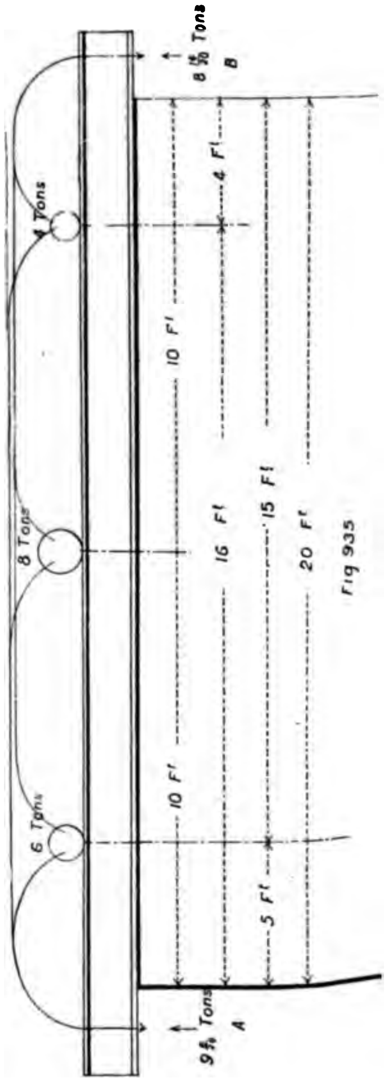


Fig 935

illustrates a girder 20 feet long, loaded with 6 tons at a point 5 feet from A 4 tons 4 feet from B, and 8 tons in the centre, making, in all, a load o 18 tons to be carried by the two supports in the proportions ascertained.

Reaction A.

$$\left.\begin{array}{llll} & & \text{tons. feet.} & \\ \text{Necessary for load of 6 tons} & = & \dfrac{6 \times 15}{20} = \dfrac{90}{20} = 4\tfrac{1}{2} & \text{tons} \\ \text{,,} \quad \text{,,} \quad 8 \quad \text{,,} & = & \dfrac{8 \times 10}{20} = \dfrac{80}{20} = 4 & \text{,,} \\ \text{,,} \quad \text{,,} \quad 4 \quad \text{,,} & = & \dfrac{4 \times 4}{20} = \dfrac{16}{20} = \tfrac{4}{5} & \text{,,} \end{array}\right\} 9\tfrac{3}{10} \text{ tons.}$$

Reaction B.

$$\left.\begin{array}{llll} \text{Necessary \textit{to complete} load of 6 tons} & = & \dfrac{6 \times 5}{20} = \dfrac{30}{20} = 1\tfrac{1}{2} & \text{,,} \\ \text{,,} \quad \text{,,} \quad 8 \quad \text{,,} & = & \dfrac{8 \times 10}{20} = \dfrac{80}{20} = 4 & \text{,,} \\ \text{,,} \quad \text{,,} \quad 4 \quad \text{,,} & = & \dfrac{4 \times 16}{20} = \dfrac{64}{20} = 3\tfrac{1}{5} & \text{,,} \end{array}\right\} 8\tfrac{7}{10} \text{ tons.}$$

6 tons + 4 tons + 8 tons = total of 18 tons

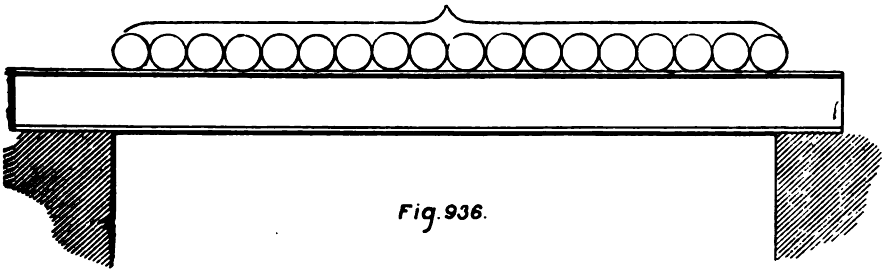


Fig. 936.

With regard to cantilevers, which have only one support, the reaction required is the same as the load to be carried by the cantilever, together with its own weight.

It will have been noticed that the principle of "leverage" plays a conspicuous part in the proportioning of the loads to the supports and their necessary reactions; and it is this same principle, in a different form, which gives us the undoubted and undisputed fact that concentrated loads cause *double* the stress and strain of the same load uniformly distributed; each part of the latter load, nearer the support, assisting to balance its outer neighbour, as it were; just as a man would carry a given quantity of water in two buckets, one on each side, more easily than he would carry it if it were all in one large bucket, and carried on one side.

For method and convenience of calculation, these distributed loads are grouped together, as it were, and reckoned as one load at its centre—*i.e.*, the centre of the distribution, as fig. 936.

The Discernment of Strains.—Common sense, consideration, and judgment are all required in distinguishing what parts of girders and the like, and what members of trusses and other framed structures, are in compression, and what parts in tension.

With regard to the first-named—*i.e.*, girders—the illustrations hereinafter given should clearly impress this distinction on the student's mind, the forms, of course, being exaggerated for the purpose.

Fig. 937 represents a girder *supported* only at each end, from which

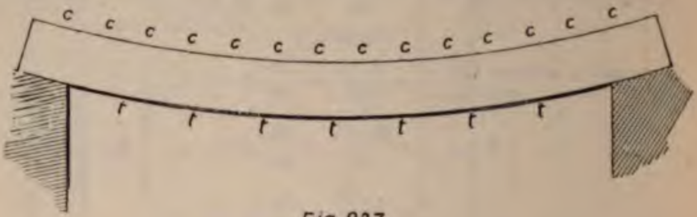


Fig. 937

it will be seen that the whole of the top flange is in compression, and the bottom flange is entirely in tension.

Fig. 938 represents the same girder fixed at both ends—showing part of each flange in compression and part in tension—the top flange being in compression in the centre, "under the load," and in tension over the ends and at the supports, while the bottom one is exactly the reverse.

Fig. 939 is a combination of figs. 937 and 938—*i.e.*, a girder having one end fixed and the other supported, showing the different results;

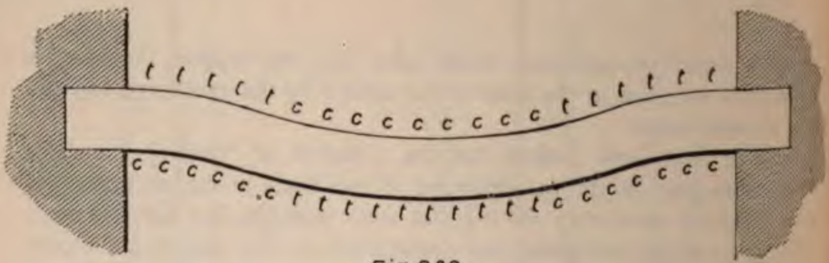

t t t t t c c c c c c c c c t t t t t t
c c c c c c t t t t t t t t t t c c c c c c c

Fig. 938.

while fig. 940 illustrates a continuous girder, having several supports, over which the top flanges, as will be seen, are in tension and the bottom ones in compression, the central portions being as usual, and as previously shown.

The best practical illustration of the above is a piece of indiarubber of sufficient length, subjected to similar conditions, etc., when it will easily be seen which part is in compression and which in tension.

Cantilevers, of course, must be fixed to hold themselves up, much

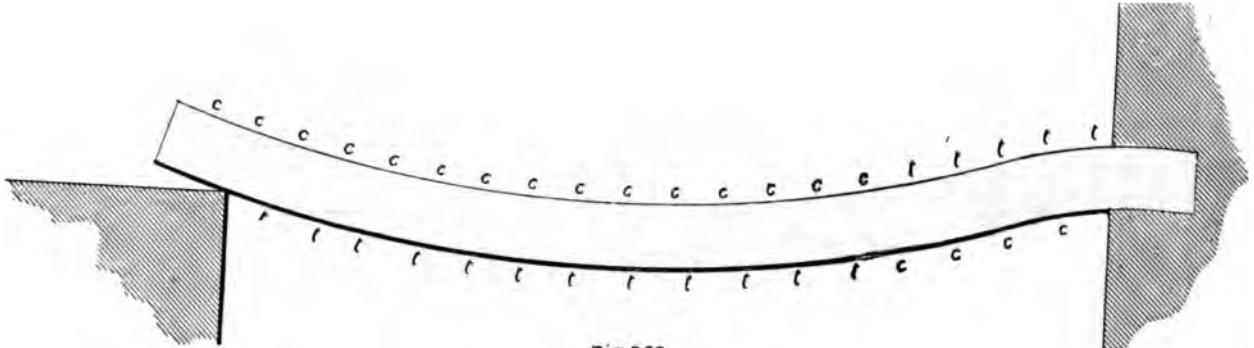


Fig. 939.

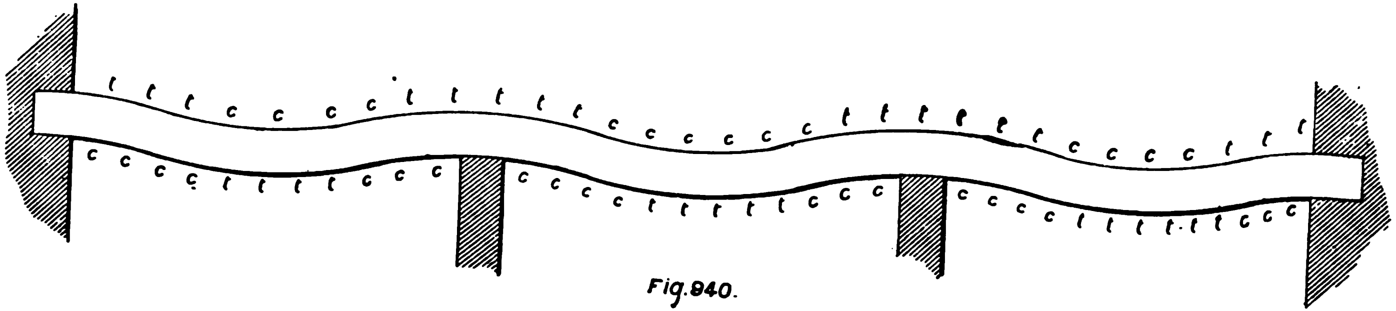


Fig. 940.

more under a load in addition; and when they are a simple projectio similar to half a girder, as fig. 941, it will be seen that they are subjecti

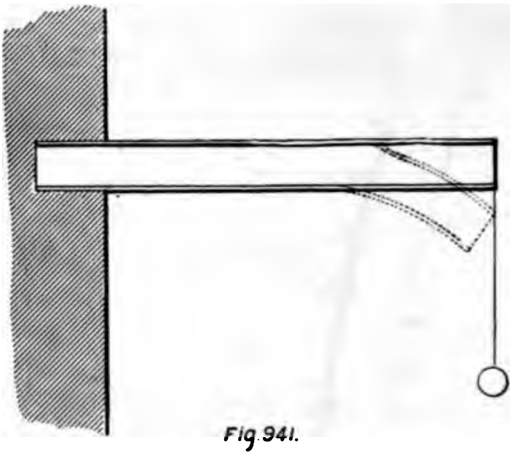


Fig. 941.

to the strains of compression and tension, resulting from loads at their en as indicated.

When they are framed it all depends on their form. Here th

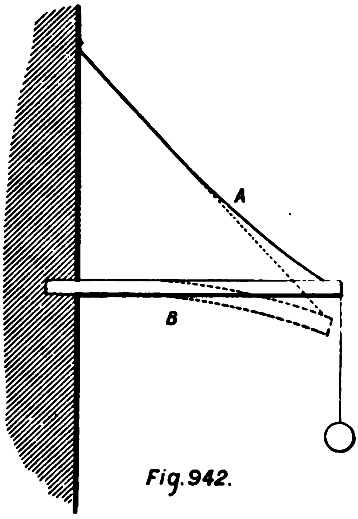


Fig. 942.

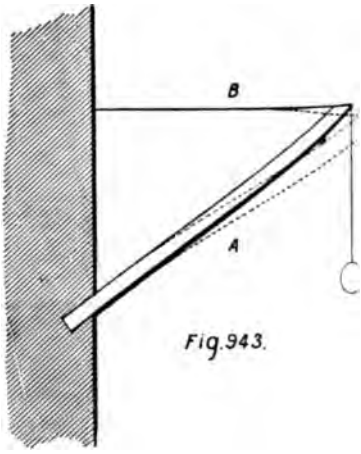


Fig. 943.

principle of considering the possibility of the substitution of rope solve all difficulties; as in fig. 942, it will be apparent that a rope would do fo the member A, which is therefore in tension; but not for B, which consequently in compression. On referring to fig. 943, it will be at onc seen that exactly the opposite is the case, A being in compression and B in tension, the dotted lines showing the effect of an excessive load.

Turning to the consideration of roof trusses, we find the application of the rope principle more useful than ever; but it should first be pointed out that the weights on roofs are, as it were, collected together and located at various points, proportionately, as fig. 944, from which it will be seen the eaves joint A take, $\frac{1}{8}$ part on each side, while the ridge C, and purlin joints B, each take $\frac{2}{8}$ or $\frac{1}{4}$ of the load.

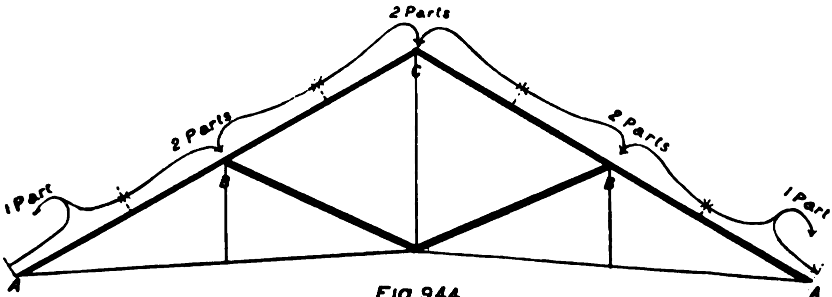


Fig. 944

To discriminate between the members in compression and tension, we find, on reflection, that a rope would certainly *not* act as an efficient substitute for the rafters or struts, as shown by thick lines, but that it might be used for the tie and suspension rods shown by thin lines (see fig. 944). Therefore the latter are in tension, and the former in compression or transverse strain.

Figs. 945 and 946 are further illustrations of trusses, the latter being the ordinary wooden king post; fig. 947 represents a trussed beam, a principle often employed to strengthen thin boards to carry flower pots, the thin line members being usually of string.

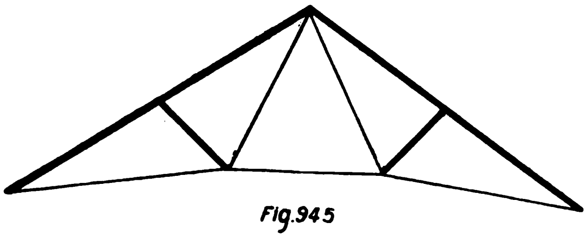


Fig. 945

Having ascertained which member or part is in tension, and which in compression, we know that wrought iron has the greatest power to resist strains tending to elongate it or tear it asunder; therefore we can do no better than use it for members in tension, and, generally speaking, it is most convenient in round or bar form, though it can be rolled into T's for struts and rafters. As regards parts in compression, cast iron, on account of its great power to resist compression, would be the strongest and best, were it not for its fragile, unweldable, and inconvenient nature, for the putting together of the joints. As a consequence, wrought iron has superseded cast iron for rafters and struts which are made of T shape, the form most suitable for long lengths, where bars or rods would bend, unless built up to make them the more rigid, as hereinbefore shown.

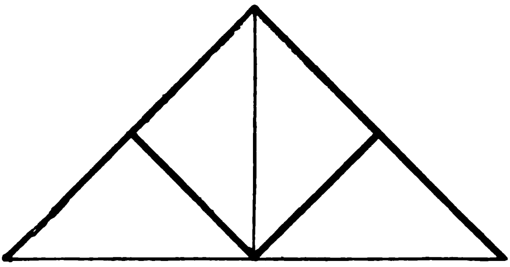


Fig. 946.

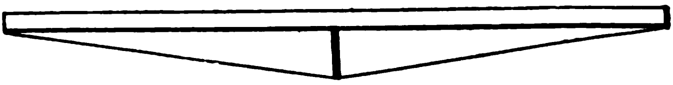


Fig. 947.

Joists, rafters, lintels, etc., subject to transverse strain (though rafters have been taken above as in compression, but only in contra-distinction to tension), are strongest when of rectangular form and of a good depth, the strength lying in the depth, and *not* in the breadth.

CHAPTER XXV.

CALCULATION OF STRAINS.

Computation of Strains on Cantilevers, Girders, and Trusses variously loaded.

Computing Strains.—The strains which the various stresses produce, as hereinbefore enumerated, can generally be calculated arithmetically and graphically, to check each other; and it is intended in this short chapter to briefly and concisely put before the student a few of the methods in vogue for that purpose.

Cantilevers—*Load Concentrated.*—Assuming that he thoroughly understands everything in the previous chapter, we will first deal with plain cantilevers of rectangular forms. Fig. 948 represents a cantilever 12 inches deep and 3 feet projection, loaded at its end by a given weight of 4 tons. The formula by which the greatest strain is calculated is $\frac{wl}{1d}$, w representing the weight, l the projection or length, and d

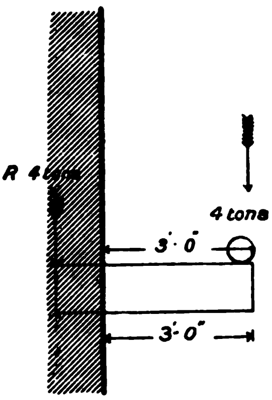


Fig 948

the depth. Therefore we have:

$$\frac{w\,l}{1\,d} = \frac{4\text{ tons} \times 3\text{ feet}}{1 \times 12\text{ inches}} = \frac{12\text{ feet}}{1\text{ foot}} = 12\text{ tons strain,}$$

which can be graphically proved as illustrated in fig. 949 and the followin

"Draw the cantilever to scale as the figure, join A B diagonally acro

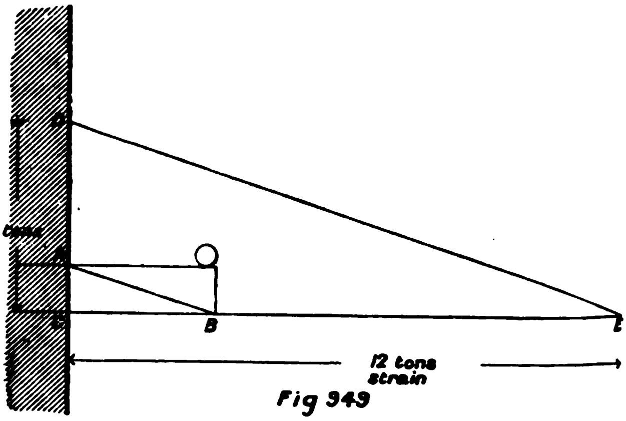


Fig 949

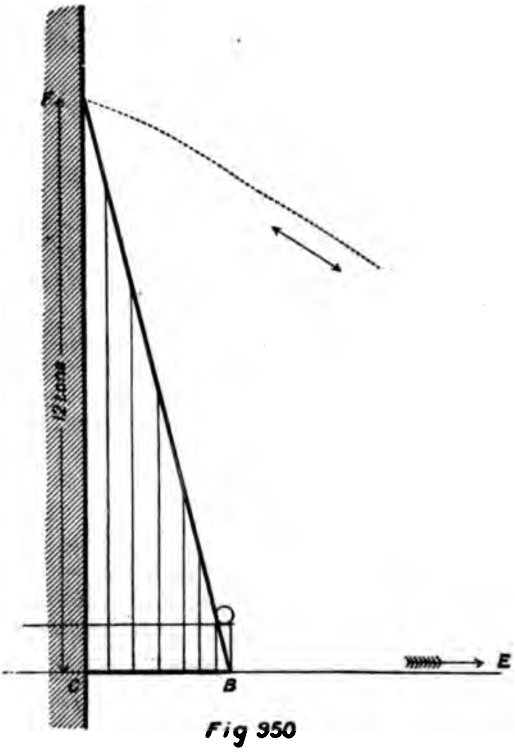


Fig 950

nd set up from C, at right angles to C B, C D, equivalent to or foot being of the same scale); then from the point D llel to A B, cutting C B produced in E, and C E will give the ain which, when reduced according to scale, will equal

ell known that the strain is greatest at the point of support, s to nothing immediately under the weight, the strains at points will graduate between the two external points of pplication of the load, so that such strains at the different oints can be ascertained according to fig. 950, the perpen- senting the strains at the points from which they are raised. o the strain line C E on fig. 949 is raised up to the perpen- F, and the points F and B are joined, forming a triangle, as represents the form of the whole strains on the cantilever, and ate perpendiculars indicate what is required.

certained these strains, we can calculate the sectional area esist them by dividing the amount of strain by the "power " of the material to be employed; always remembering that , or part, has to resist the amount of one strain (tension) and rt the same amount of the contrary strain (compression), to ther of which every part is subjected, according to circum- ereinbefore explained.

iron will resist safely	4	tons	compression	per superficial inch.
„	5	„	tension	„
„	1½	„	„	„
„	8	„	compression	„
„	6	„	„	„
„	6	„	tension	„
„ (about)	16	cwt.	„	„
„ „	13	„	compression	„
„ „	10	„	„	„
„ „	12	„	tension	„
„ „	10	„	„	„
„ „	7	„	compression	„

, according to the table, the top flange, if in wrought iron, an area of 2⅖ superficial inches, to resist 12 tons of tension; om flange 3 inches in area, to resist the same amount of

If fir were used it would require to be 12 inches deep (a ccording to your calculations, which assume it as 12 inches), broad, giving an area of 60 square inches, 24 of which are 10 cwt. per square inch) to resist 12 tons of tension, while g 36 square inches would be required to resist 12 tons of (at 7 cwt. per square inch) on the lower part.

Theoretically the cantilever might be constructed as fig. 951 or fig. 952; but this is not done in practice, as a rule.

—*Load distributed.*—Coming to uniform loads on cantilevers, it is usual to take the collected load, or total weight, as located in the centre of the loaded area, as fig. 953, from which it will be seen that it is in this case practically halfway along the cantilever, and the formula resolves itself into $\frac{wl}{2d}$, twice the depth being taken to give the "half" result as compared with a concentrated load; for we know that the latter causes double the strain of a uniform load. Therefore—

$$\frac{w\,l}{2\,d} = \frac{4 \text{ tons} \times 3 \text{ feet}}{2 \times 1 \text{ foot}} = \frac{12}{2} = 6 \text{ tons strain.}$$

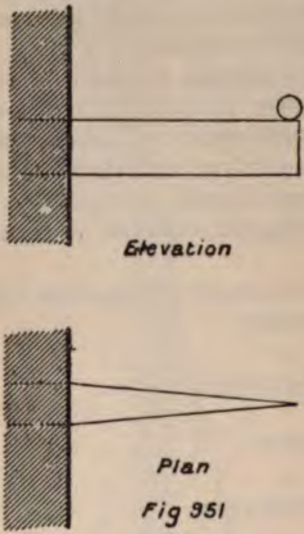


Fig 951

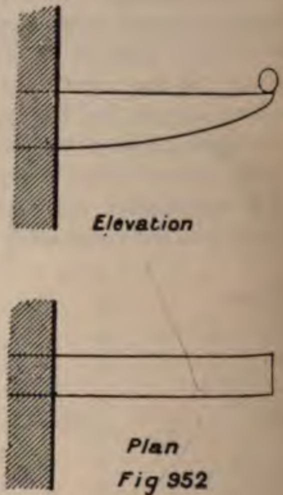


Fig 952

Graphically this is ascertained by a similar process to fig. 950, the diagonal being raised from a point halfway along the bottom flange, as fig 953, while the graduation of the strains at intermediate points takes the form of a concave parabolic curve, as shown on fig. 954, which should need no further explanation.

The theoretical form of the cantilever would be either as fig. 955 or fig. 956.

—*Two distinct loads.*—If two distinct loads are placed on a cantilever their strains should be calculated separately, and the results added together; while graphically they should be treated as fig. 957, of which the small diagram is constructed, to give the lines of inclination to the figure. A lar is dropped from any point as Z, and on it are marked off ely from the point the weights or reactions of the loads, Z Y ng to scale 1 ton, and Y X 2 tons. The depth, which always

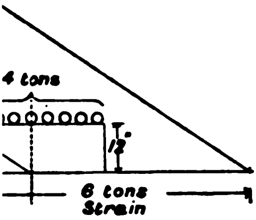


Fig 953

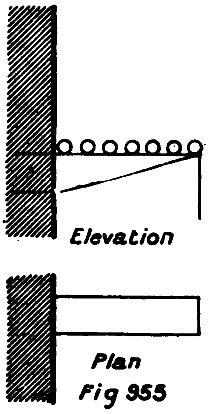


Fig 955

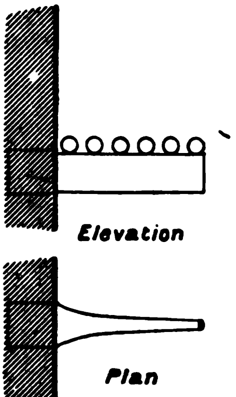


Fig 956

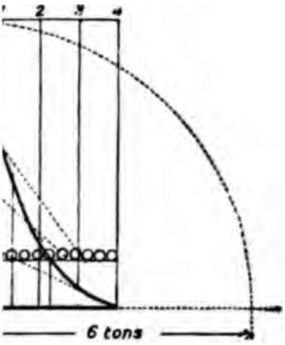


Fig 954

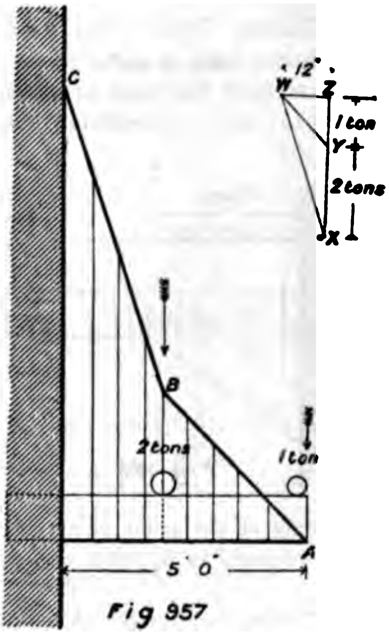


Fig 957

n a conspicuous part, is marked off at right angles to Z X from nd then W Y and W X are joined. Reverting to the main figure, e draw A B parallel to W Y until it meets a perpendicular raised from the other load; after which A B is continued to C, but parallel to W X. Thus the diagram is formed, and the strains can be scaled off as required. If the cantilever were uniformly loaded, it would be treated similarly to fig. 954 in principle.

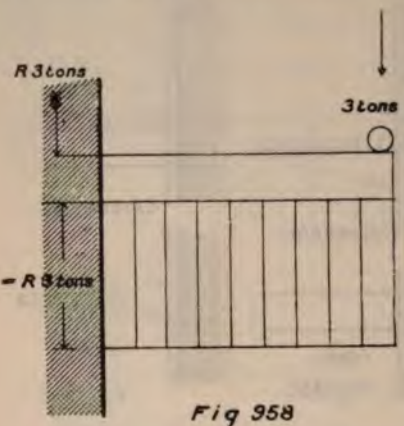


Fig 958

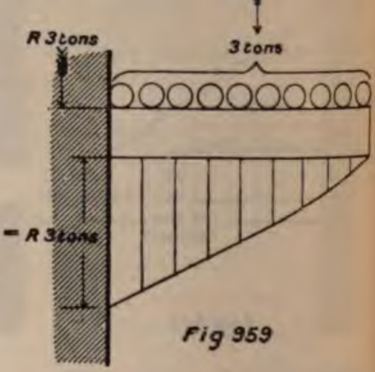


Fig 959

—*Shearing Strain.*—The "shearing" strain on a cantilever, with a concentrated load, is equal to the amount of the reaction all along the cantilever from the point of support to that of application of the load, as fig. 958; while, on uniformly loaded cantilevers, it gradually diminishes to nothing at the point of application from the amount of the reaction at the support, as fig. 959, one part of the load assisting the other, as it were.

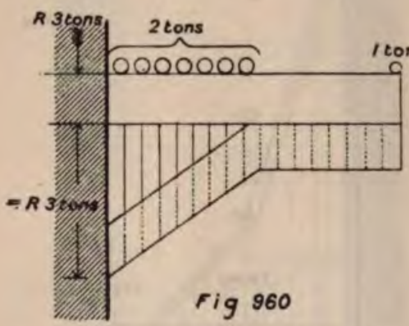


Fig 960

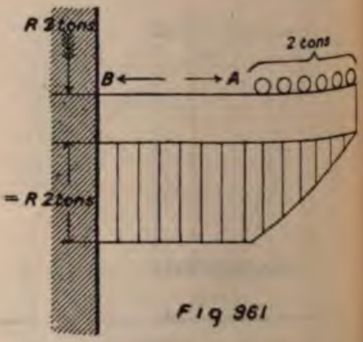


Fig 961

—*Two distinct Loads.*—A cantilever differently loaded at two or more points would have its "shearing" strain shown, as fig. 960; and if a uniform load is fixed at a distance and clear space from the support, it will be as fig. 961, taking the form of a concentrated load from A to B.

ders.—Girders are treated in a similar manner to cantilevers, their)eing ascertained by the following formulæ:—

$\frac{w\,l}{4\,d}$ for concentrated loads,

$\frac{w\,l}{8\,d}$ for uniform loads.

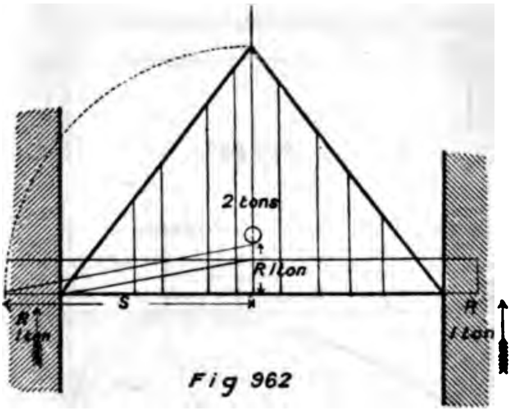


Fig 962

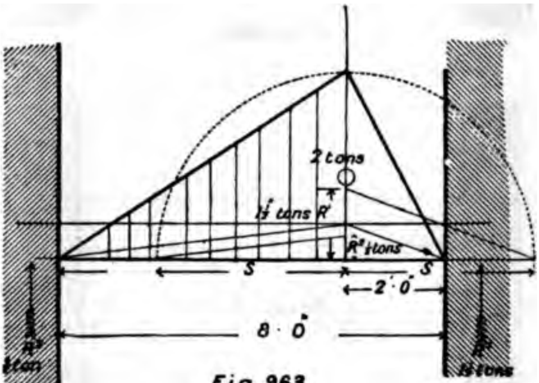


Fig 963

t a girder of 8 feet span and 9 inches deep, supporting a uniform f 2 tons, would have its strain calculated thus:—

$$\frac{wl}{8\,d} = \frac{2 \text{ tons} \times 8 \text{ feet}}{8 \times 9 \text{ inches}} = \frac{16 \text{ feet}}{6 \text{ feet}} = 2\tfrac{2}{3} \text{ tons strain,}$$

would be doubled if concentrated.

ıphically, a girder, with concentrated load centrally, would be dealt with as fig. 962, and as fig. 963 if intermediately loaded; while fo

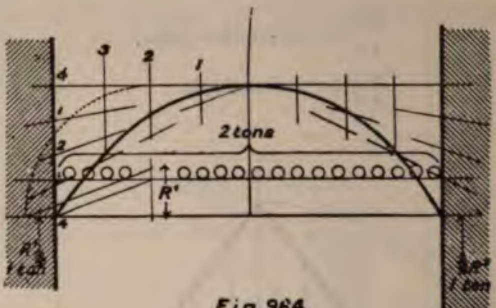


Fig 964

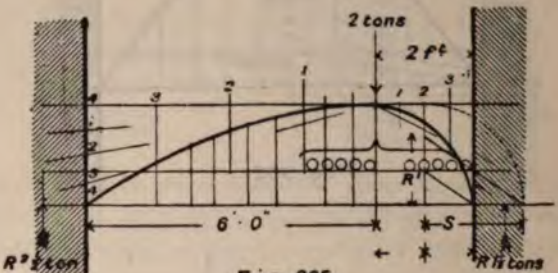


Fig 965

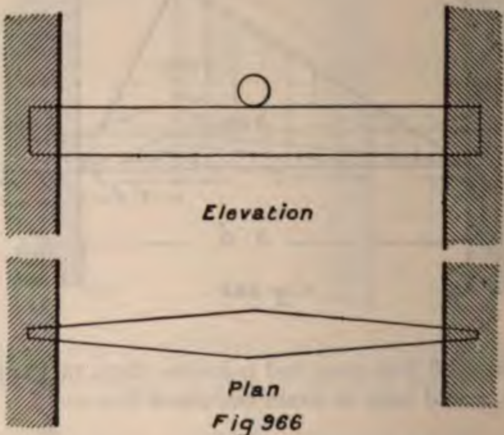


Fig 966

uniform loads it would be as figs. 964 and 965 respectively; one half the load (or either of the reactions) being set up as the height, when reactions are equal; and, when they vary, one or the other will answer

, so long as care is taken that the same side of the load is

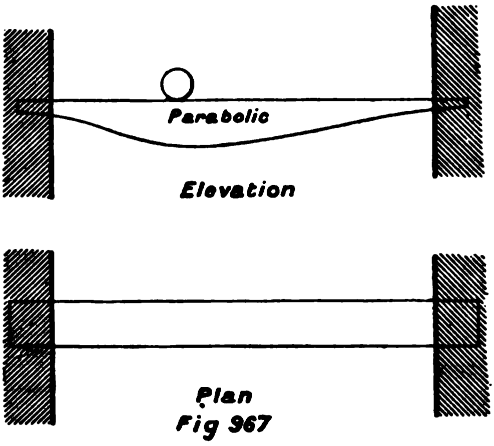


Fig 967

for the diagonal and parallel line to ascertain the strain, as arly illustrated on fig. 963. If correct, figures will always com- emselves.

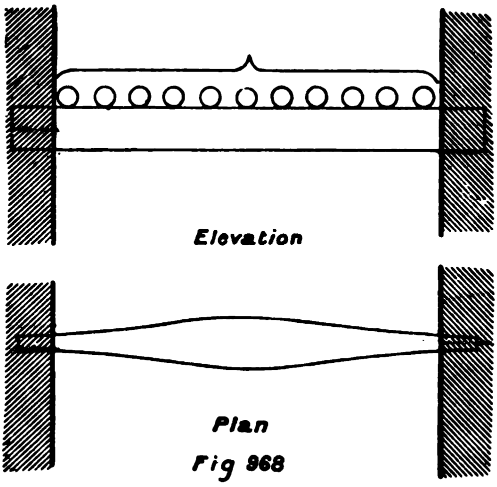


Fig 968

theoretical outlines for beams or girders are as figs. 966 and 967 entrated oads, and figs. 968 and 969 for uniform loads.

—*Under several distinct Loads.*—When a girder is loaded with several different loads the strains are found graphically, as fig. 970 (similarly to fig. 957); and, arithmetically, they are proved by working each load out separately and adding the results together. On fig. 970 it will be noticed that, in the small diagram, the perpendicular line of loads is divided proportionately to the reactions, and the depth line thrown out at right angles from that point. The other working is precisely the same as fig. 957.

Graphic diagrams in this class of work are also of service to the designer, in that they help him to economise judiciously by riveting plates on, intermediately, along the flanges, to withstand irregular strains without increasing the general sectional area. For instance, the diagram of strains, fig. 971, clearly points out that an additional plate of sectional area, to resist the strain indicated by A B, and of a length equivalent to C D, can be judiciously added to the length of girder E F, designed to resist a strain amounting to G H.

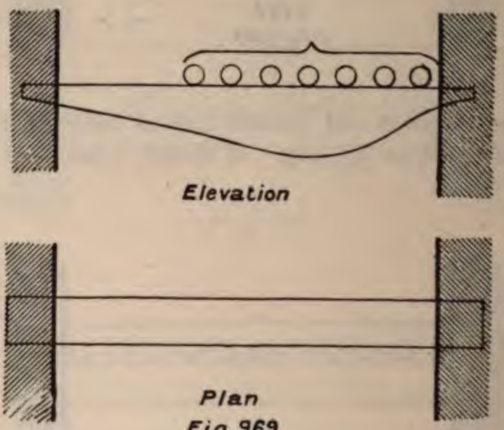


Fig 969

Sometimes we have, in practice, to find out, by calculation or stress diagrams, the strains caused by certain loads at various intermediate points along a girder; and this is done mathematically by multiplying the reaction by the distance from the support, and dividing the result by the depth; while it is graphically treated (alternatively to figs. 962 to 964, where the perpendiculars are scaled) as fig. 972, which represents a girder of 12 feet span, 2 feet deep, loaded centrally with 10 tons (though this rule is applicable to any weight and position), and it is required to find the strain caused by the load at every 2 feet.

irder is drawn to a scale by which feet and tons are made equiva-
l, perpendicularly upwards from A on the bottom flange, at the
upport, a line A B is measured to represent the reaction at that

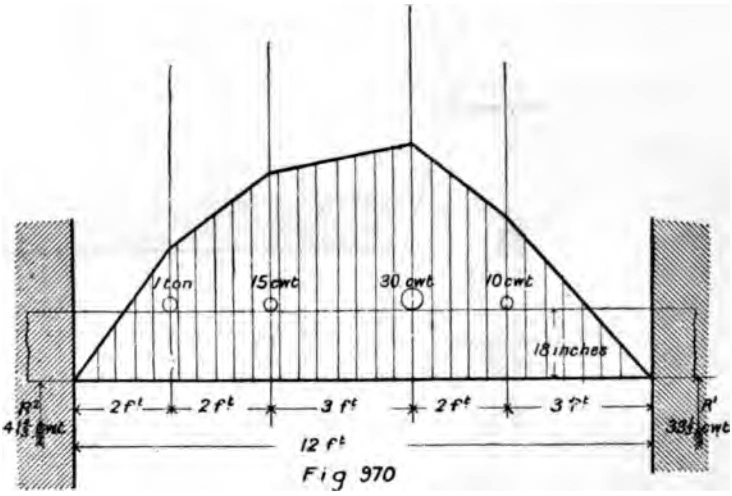


Fig 970

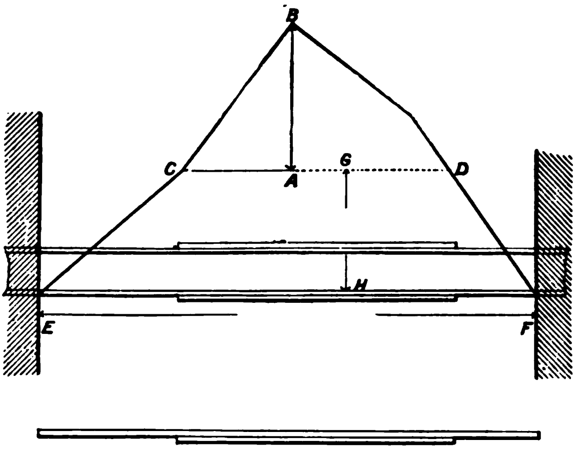


Fig 971

; and, from the top point B, a line is drawn across, parallel to the
nd of indefinite length. The points at which it is required to find
n are marked off along the top flange; and from A a line is drawn

through each one to the indefinite line from B, and the distance from B cut off by that intersecting line from A, gives the required answer whe

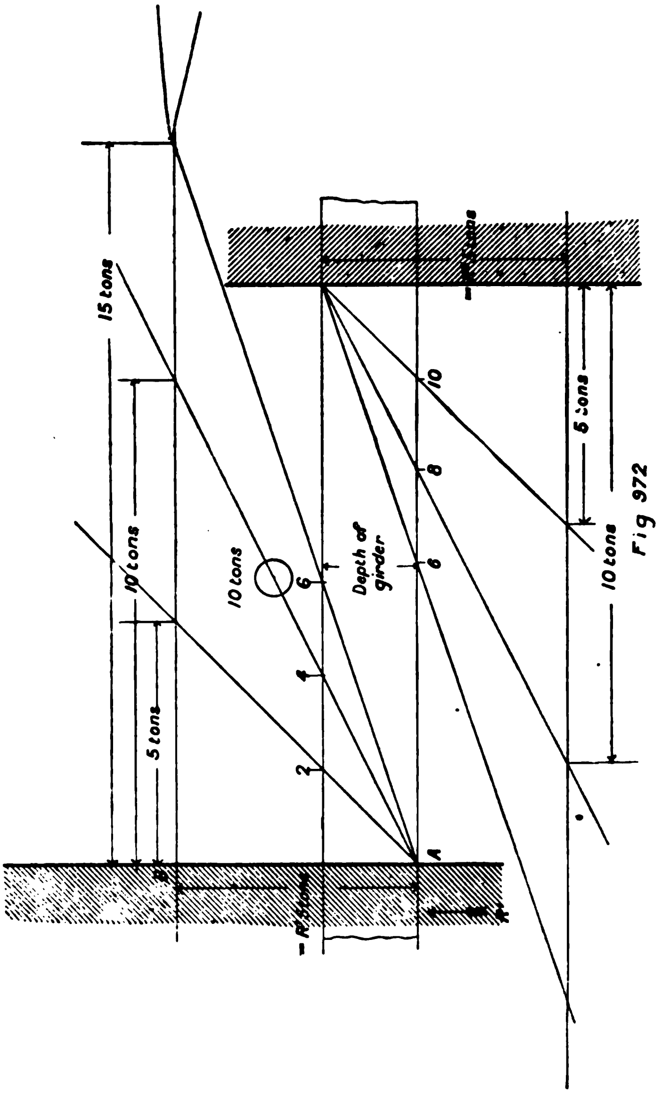


Fig 972

reduced to weight according to scale. The strains on the bottom flange are worked out conversely to the above, as shown on the lower part of the gure; though this is not necessary, as the strains on both flanges are like in amount, only different in character.

Proof of this is obtained by calculation on lines just laid down:—

$$\frac{\text{5 tons reaction} \times \text{2 feet from support}}{\text{depth of 2 feet}} = \frac{10}{2} = \text{5 tons strain 2 feet away.}$$

$$\frac{\text{5 tons reaction} \times \text{4 feet from support}}{\text{depth of 2 feet}} = \frac{20}{2} = \text{10 tons strain 4 feet away.}$$

If the load be placed at any intermediate point between the supports he reactions of course are unequal, but when multiplied by the distance of he load from each point of support, the same result should be given.

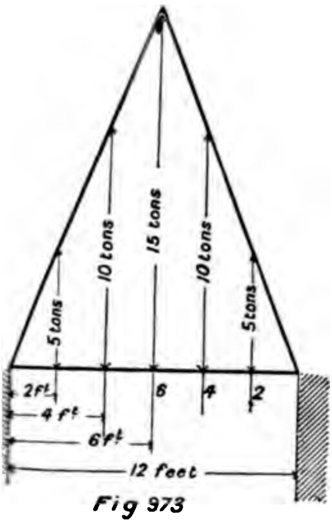


Fig 973

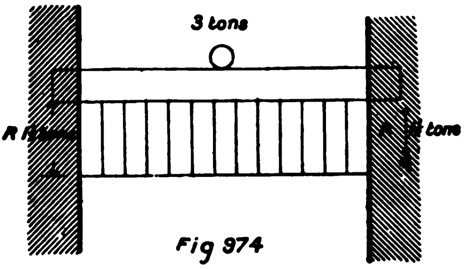


Fig 974

For, supposing this girder were loaded 3 feet from one support, the reactions would then be in the proportion of 3 and 9 (to make up the 12 feet)—*i.e.*, they would be respectively 7½ tons and 2½ tons, which give the same result when multiplied by the distances away as 7½ tons × 3 feet, and 2½ tons × 9 feet, each equal 22½ tons strain under the load; and the strains, at any intermediate points between load and supports, can be ascertained in like manner by multiplying the reaction by the distance the point (at which it is required to find the strain) is away from that support. Fig. 973 represents the form of the strains on the girder in fig. 972.

The—*shearing*—on girders is equal to the reaction at each support from the centre or load to that support when it is a concentrated load; while a uniform load causes a gradual *shearing* from nothing immediately under it to the amount of the reaction at the support, as figs. 974, 975, 976, and 977, will explain. So that, in the latter case, the "shearing" at any point is equivalent to the amount of load distributed between that point and the centre.

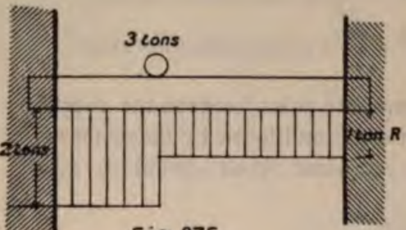


Fig 975

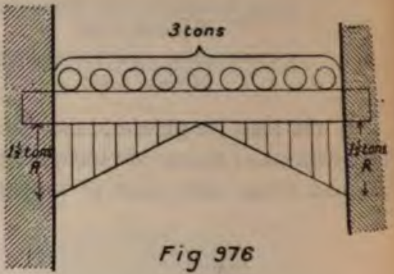


Fig 976

Framed Structures.—Coming to framed structures, the student must thoroughly understand, and never lose sight of the fact, that "the forces acting at any point, to be in equilibrium (which is the foundation of the structure), must complete and form a triangle or polygon whose sides are parallel to the directions of the forces, and therefore are equivalent to their magnitudes."

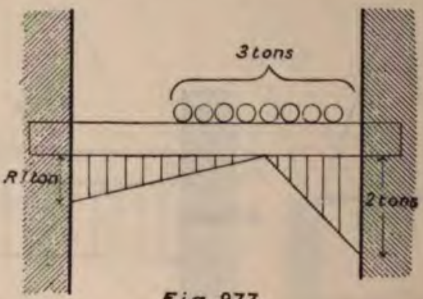


Fig 977

Triangle or Polygon of Forces.—This theorem is the foundation of all calculations and diagrams, as will hereinafter be illustrated (*vide* figs. 979 to 984), though these reciprocals (as they are sometimes called) will, of course, be pointed out, as the diagrams are constructed, in the usual way.

Roof Trusses.—It is only proposed here to deal with roof trusses, as other framings do not, strictly speaking, belong to building construction.

The first procedure is to locate the weight at various points, and then ascertain the reactions (as should always be the first thought in whatever class of work), the polygon of forces (as fig. 990) being used to determine the necessary reactions. But when the loading is vertical and equal on both slopes of the roof, each reaction will be equal to one half the total l, so that the polygon of forces becomes a straight line, obviating her trouble, which, it will hereinafter be noticed, is present in unequal ing.

—*King Post Truss.*—Taking a "king post" truss as our first form, we eed as follows:—

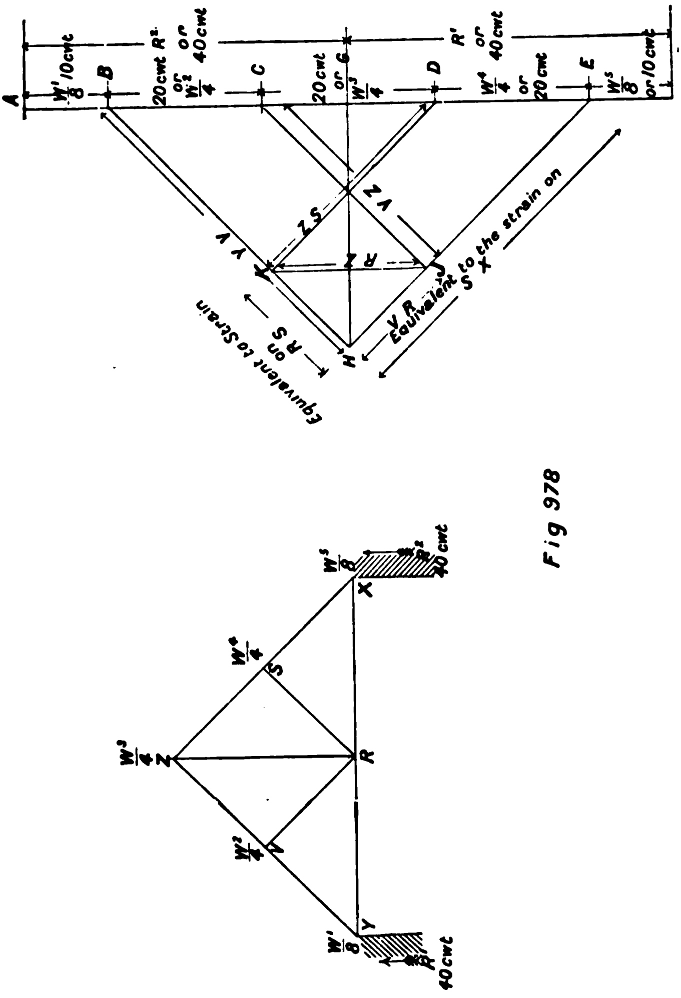


Fig 978

Set up any line vertically in any position as a line of loads, and assuming the truss carries 4 tons weight, it will be divided as $\frac{w}{4}\,\frac{w}{4}\,\frac{w}{4}\,\frac{w}{8}$ and $\frac{w}{8}$, iagram 978; so that we shall have to support 1 ton of it at each purlin and the ridge, with ½ ton at each of the eaves to equally divide the 8 tons. Therefore the reactions will be :—

$$\frac{\frac{\overset{4}{w}}{4}+\frac{\overset{2}{w}}{4}+\frac{\overset{3}{w}}{4}+\frac{\overset{1}{w}}{8}+\frac{\overset{5}{w}}{8}}{2}=\frac{\overset{\text{cwt.}}{20+20+20+10+10}}{2}=\frac{\overset{\text{cwt.}}{80}}{2}=40\text{ cwt. each.}$$

Starting from A on the line of loads, we set off to scale A B $=\frac{w^1}{8}$; B C $=\frac{w^2}{4}$; C D $=\frac{w^3}{4}$; D E $=\frac{w^4}{4}$; EF $=\frac{w^5}{8}$; and, bisecting A F in G, we have A G and G F equivalent to R^1 and R^2—*i.e.*, 40 cwt. each, measured from each end.

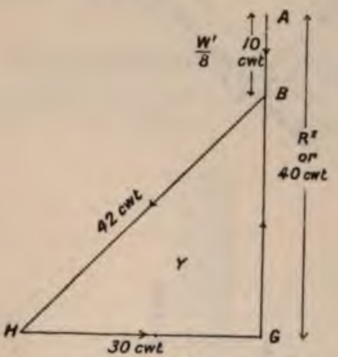


Fig 979

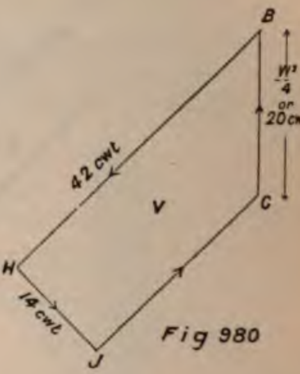


Fig 980

From B we then draw B H, and from G G H, parallel to Z Y and Y R, respectively; giving us A B H G A as the reciprocal of the forces at the joint Y, while B H and H G give us (according to scale) the strains on Y V and Y R respectively.

Next, taking the joint V, we draw H J and J C parallel to V R and V Z, giving us B C J H B as the reciprocal of V, with H J and J C equivalent to the strains on V R and V Z.

Following with joint R, we draw J K parallel to R Z, making G H K J H G reciprocal to R, with J K equivalent to R Z, which gives us the strains on half the members; and since the loading is equal, the strains are equal on the other half, which is completed on the diagram; and all that now remains to be done is to scale off the strains and calculate the material required to resist them in the usual way.

Figs. 979 to 984 give the polygons of forces at the various joints in equilibrium; the arrows indicating the directions, for all forces must go one way round the polygon, beginning at any one point; though they must continue until they close to be in equilibrium.

Each figure is a "reciprocal" of the joint of which it carries the corresponding letters, and each line forming the figure represents a force acting at the joint as A B (fig. 979) represents that at the eaves, B H that on the lower part of the rafter, H G that on part of the tie-rod, and A B the upward reaction of the support.

This subject will require careful study and reasoning, for it must be clearly understood and mastered, as this principle is, as it were, the very foundation of our work.

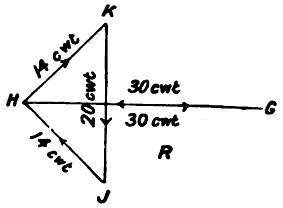


Fig 981

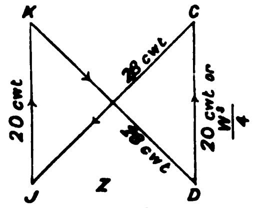


Fig 982

The amounts of the strains are figured on the polygons, which are all drawn to scale similar to the diagram 978. This must always be done most carefully and accurately, for slight inaccuracies often end in large errors, on account of the dependence of one line on another.

It will be noticed that the weights and reactions play their part and belong to these polygons, for they are known forces, which close the sides, and where they occur they have been marked accordingly.

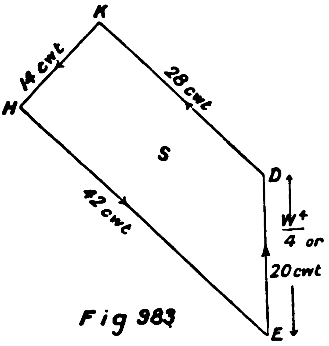


Fig 983

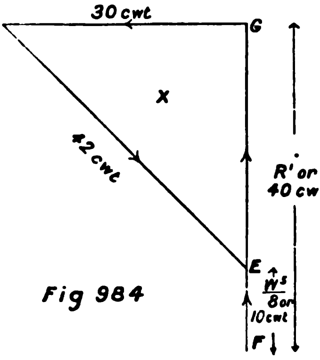


Fig 984

—*Queen Post Truss.*—Fig. 985 represents the diagram for a "queen post" truss ($\frac{w}{12}$ being equivalent to 10 cwt. and $\frac{w}{6}$ 20 cwt.), which should explain itself; *a b c d a* being the reciprocal of A, *b c e f b* of B, *d c e g d* of E, *f h j g e f* of C, *h k j h* of D; the others being similar, as the truss is equally loaded.

A larger truss, with more framing, is depicted in fig. 986, with diagram, from which it will be gathered that *a b c d a* is the reciprocal of A, *b c e f b* that of B, *d c e g d* of C, *f e g h j f* of D; while *j h k l j* and *d g k h g d* represent E and F respectively. The other part has been left out intentionally, to save confusion; it is practically a repetition of the other half.

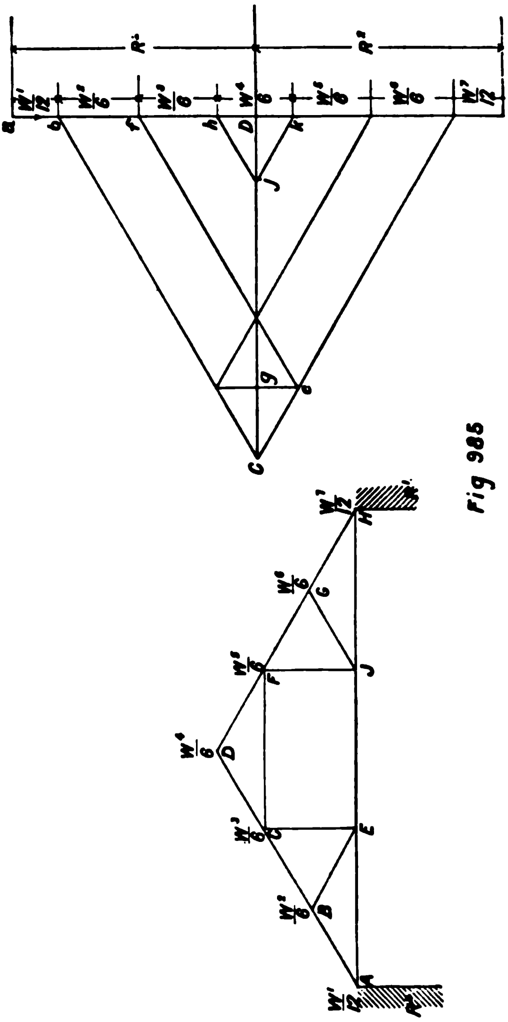


Fig 985

Fig. 987 represents a similar truss, with a cambered tie rod, the diagram for which will illustrate what a difference it makes compared with the

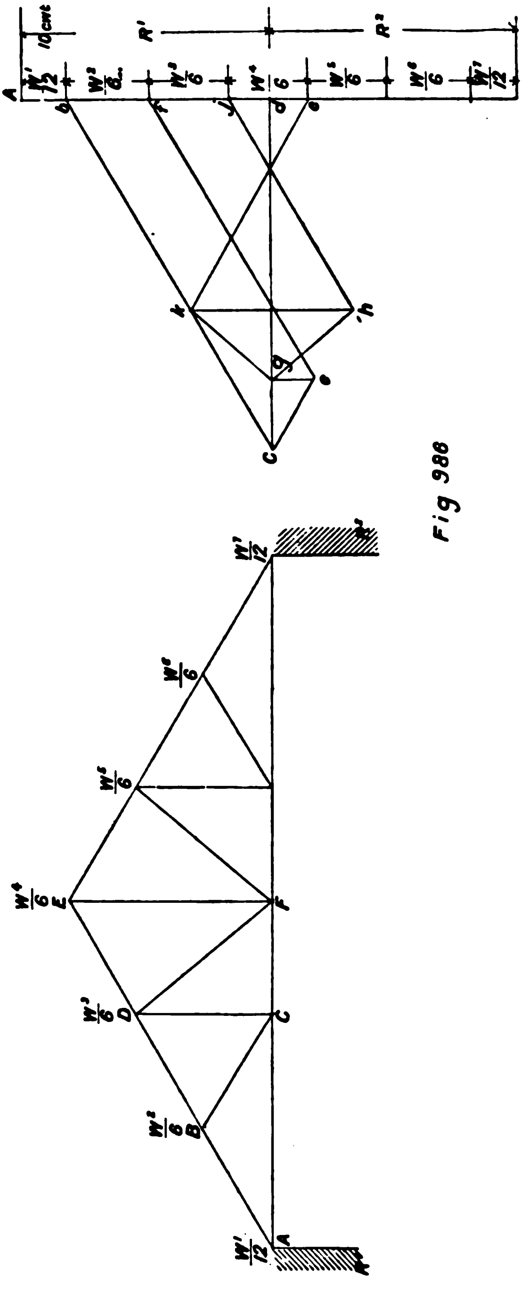

A
W¹/12
10 cwt
R¹
R²
b
W²/6
f
W³/6
j
W⁴/6
d
e
W⁵/6
W⁶/6
W⁷/12
k
h
g
c
W¹/12
A
R¹
W²/6
B
W³/6
D
C
W⁴/6
E
F
W⁵/6
W⁶/6
W⁷/12
R²

Fig 986

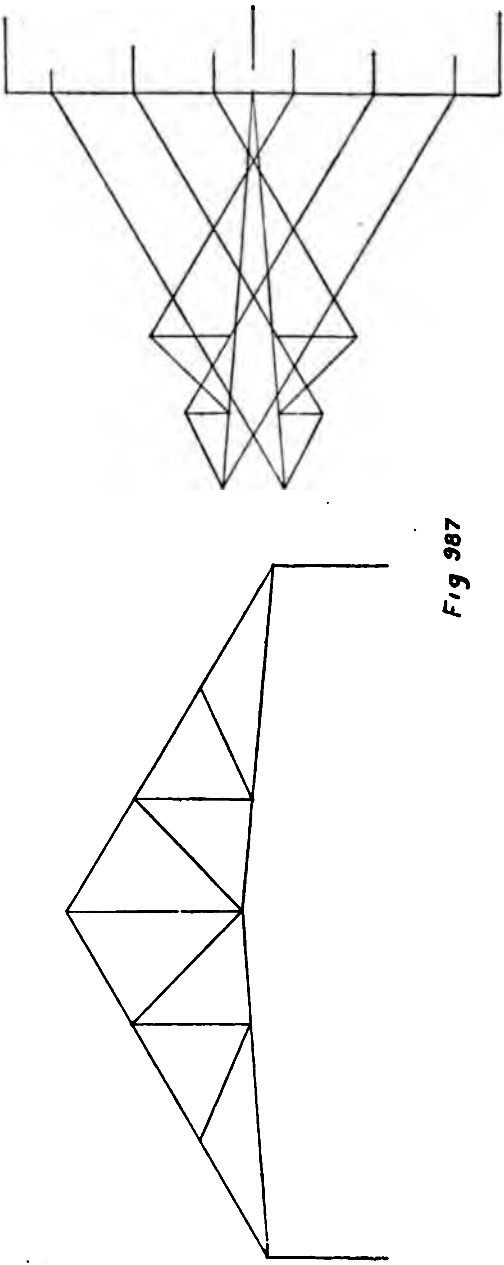


Fig 987

aight rod. The student must work out, or rather "identify the recipro- ls" for himself. It is precisely similar to fig. 986.

The next form of roof truss treated will be as fig. 988; and as this is a ss in common use, the writer will take this opportunity of dealing with equal loading, hereinafter using this truss.

Having located our weights, and ascertained the reactions in the usual ay, as hereinbefore explained, we draw the diagram as shown in fig. 988, om the vertical load line, and parallel to the members of the truss; the ciprocals formed thereby representing the joints as follows:—*a c g o a* = A; *h d c* = B; *d h t l e d* = C; *o t h g o* = F; *o t l k o* = G; *e l k f e* = D; and *f k o b* = E; all of them closing together as required. The strains can found by scaling off the corresponding members in the diagram in the dinary way.

Hitherto no distinction has been made between lines in compression d those in tension, because the distinction was too apparent; but they e shown in figs. 988 and 989 by thick and thin lines respectively.

—*Special loading.*—It will be seen that in fig. 989 two loads of 20 cwt. hung from points F and G of the truss in addition to the previous ding, which, of course, alters the diagram considerably as shown, and reases the reactions which remain equal—*i.e.*, 60 cwt. each, as compared h 40 cwt. on fig. 988.

On the usual line of loads mark off the loads on the truss, neglecting suspended loads, and from each end of the line set up and down the ctions to scale, making *a v* and *b y*, which cross each other, as will be ticed. This done, we proceed in the usual manner, drawing *c g* from C allel to A B, and from V (the reaction point) drawing *v g* parallel to A F, king *a c g v a* the reciprocal of A; while further parallels will give us *h d c* for B, *d h t l e d* for C, and *o y g h t o* for F, as compared with *o t h g o* fig. 988, the latter containing four forces, while this contains five. The er joints at D E and G are similar to A B and F, while the line *t o* is mmon to both halves of the truss and the joints F and G.

—*Unsymmetrical loading.*—When we come to unequal and unsymme- al loading we meet with a difficulty at the very beginning; inasmuch we have hitherto used no means, except calculations, to ascertain the ctions; and this is done by means of a *funicular* and polygon of forces.

A line is set up, just as a "load" line—viz., as Z Y (see fig. 990)—and it are marked off the loads, as *z o*, *o p*, and *p y*, equivalent to W^1, W^2, d W^3, on the truss; after which "any" point X is taken, somewhere vel with the centre of the load line Z Y, but no less than its length ay, and we join X *o*, X *p*, X *y*, which are called *vectors*; then drop per- endiculars from the points of loading and reaction on the truss, after hich we draw 1.2, 2.3, and 3.4, parallel to X *p*, X *o*, X *z*, on the *funicular* connect these perpendiculars; and by joining 1.4 we complete the polygon of forces; and parallel to the latter we draw X R on the funicular from X to the load line, the intersection determining the magnitude of the reactions R^1 and R^2.

The reactions are then transferred to the ordinary load line, from which the diagram is drawn in the usual way; the resulting reciprocals *a b e o a*, *b e f c b*, *c f t k d c*, *o e f t o*, *o t k o*, *d k o d*, representing the forces at A, B, C, D, E, and F. The diagram shows that there is no strain on E G, and that the strains on C G and G F are alike.

Having mastered these few examples, the student ought to be able to deal with all ordinary strains on building structures.

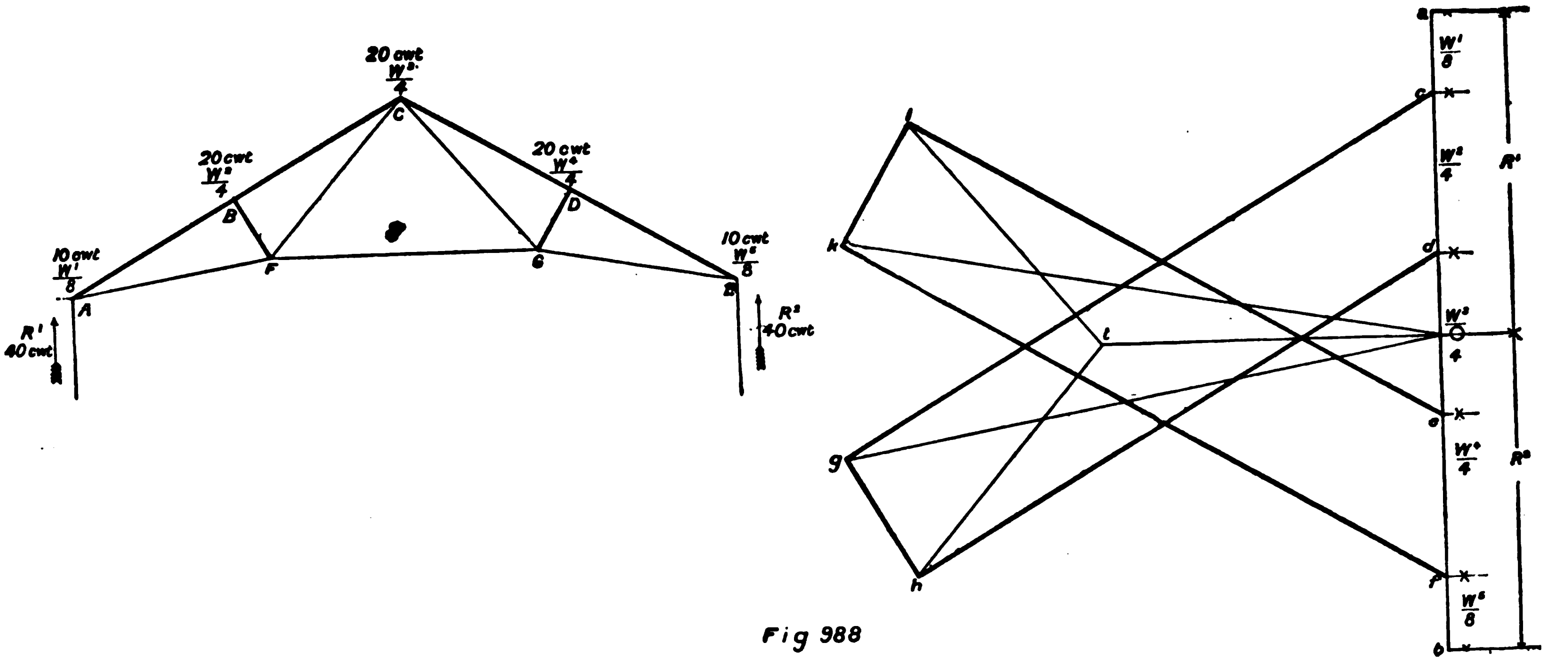

20 cwt
$\frac{W^3}{4}$
C
20 cwt
$\frac{W^2}{4}$
B
20 cwt
$\frac{W^4}{4}$
D
10 cwt
$\frac{W^1}{8}$
A
10 cwt
$\frac{W^5}{8}$
E
F
G
R¹
40 cwt
R²
40 cwt
a
b
c
d
e
f
g
h
k
l
t
$\frac{W^1}{8}$
$\frac{W^2}{4}$
$\frac{W^3}{4}$
$\frac{W^4}{4}$
$\frac{W^5}{8}$
R¹
R²

Fig 988

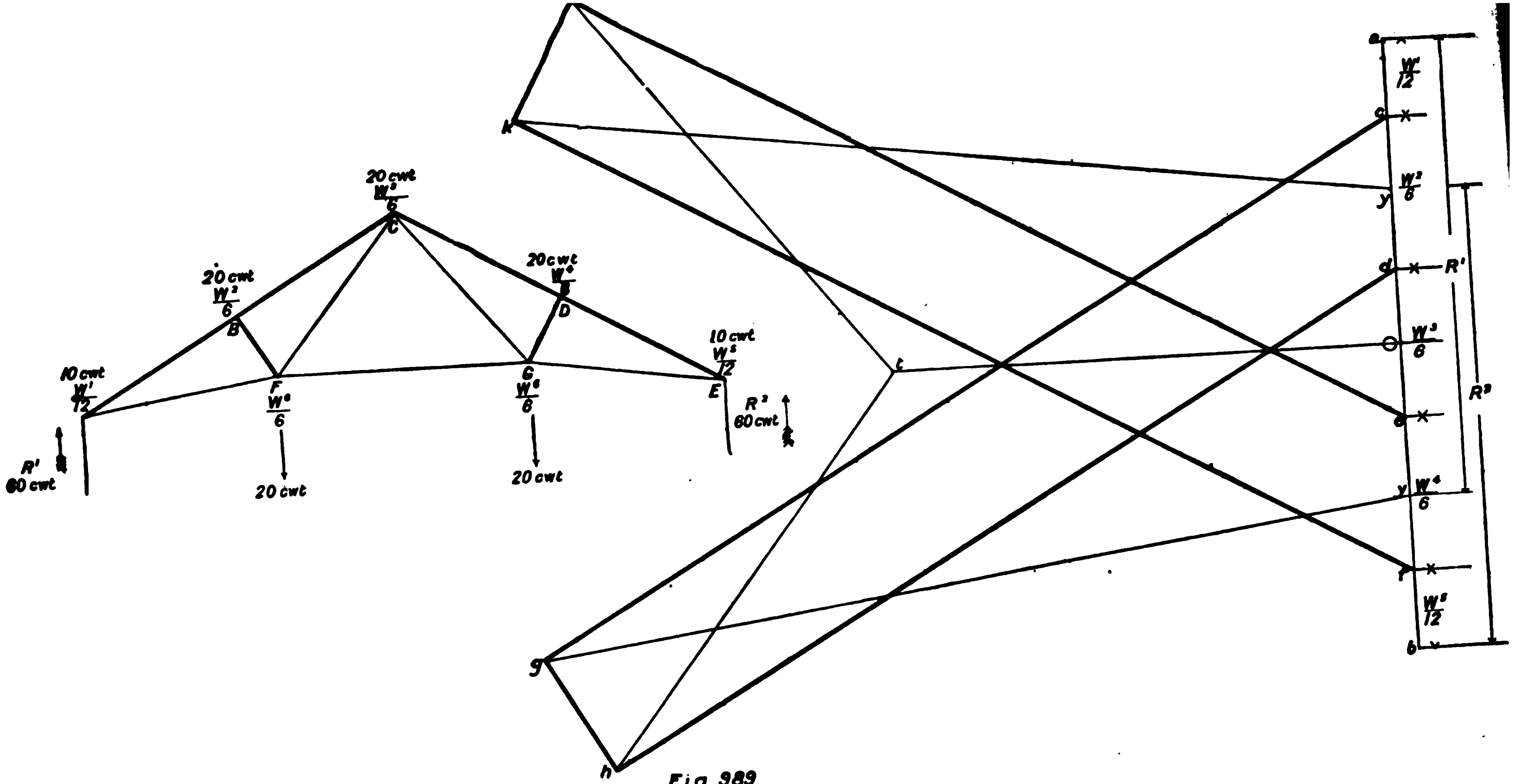

10 cwt
W¹/12
R¹
60 cwt
20 cwt
W²/6
B
20 cwt
W³/6
C
20 cwt
W⁴/6
D
10 cwt
W⁵/12
E
R²
60 cwt
F
W⁶/6
20 cwt
G
W⁶/6
20 cwt
k
g
h
t
a
c
y
d
e
y
f
b
W¹/12
W²/6
W³/6
W⁴/6
W⁵/12
R¹
R²

Fig 989

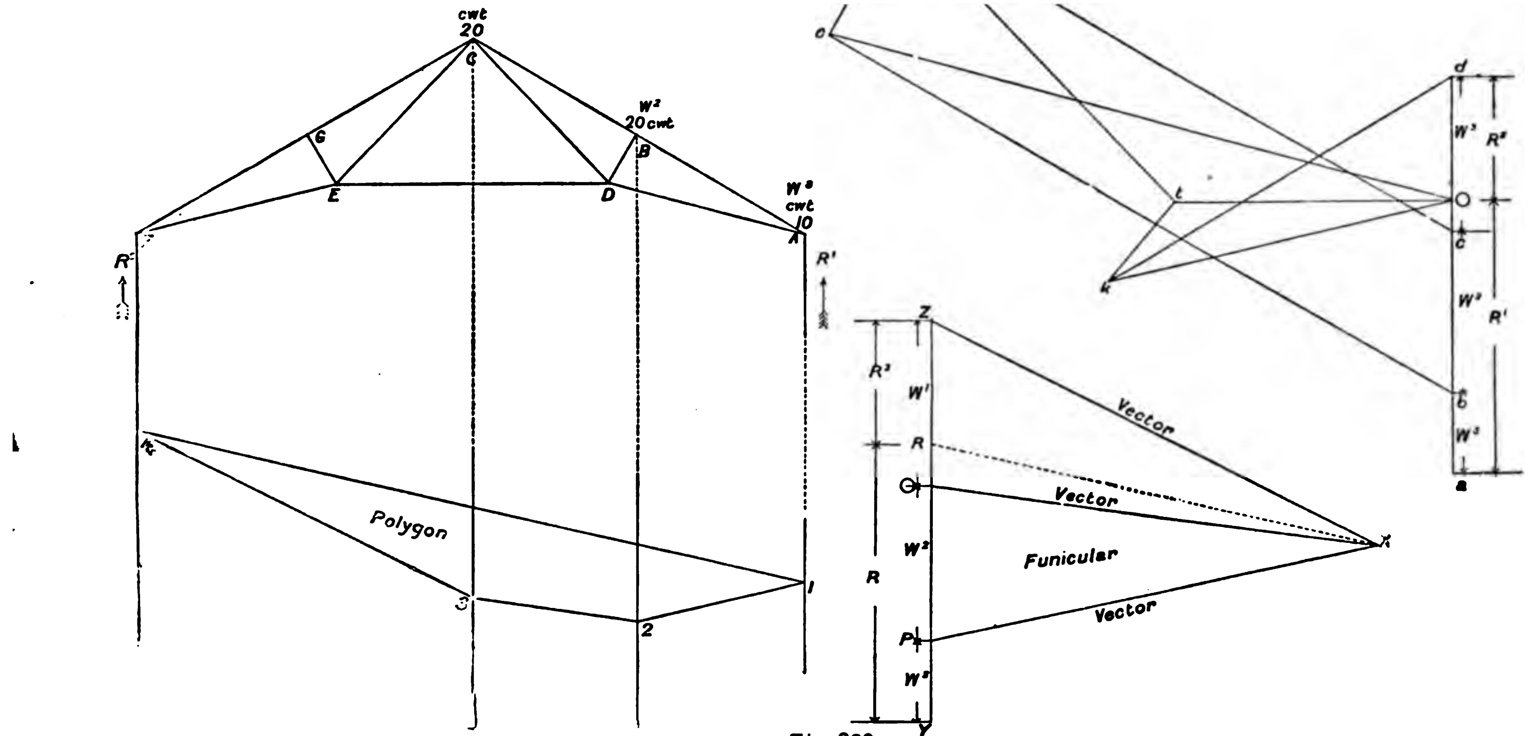

cwt
20
C
G
E
D
W²
20cwt
B
W³
cwt
10
A
R²
R¹
Polygon
1
2
3
o
t
k
d
W³
R²
O
c
W²
R¹
b
W¹
a
Z
R²
W¹
R
O
W²
R
P
W³
Y
Vector
Vector
Funicular
Vector
X

Fig 990

CHAPTER XXVI.

SANITATION.

Model Dwelling—Air and Ventilation—Draughts—External Ventilators as Inlets—Ventilating Fans—Drainage—Traps—Drain Pipes and Testing—Inspection Openings and Ventilation Inlets—Ventilation Outlets—Flushing—Cesspools—Sewage Irrigation—Water Closets and Soil Pipes—Baths—Water Supply.

is is one of the vexed subjects of the age; though it must be under- od that the great differences of opinion only take place as to the ans and methods by which it is attempted to get rid of evils, which, and all agree, exist in a greater or less degree, in connection with dwellings which belong to the present decade.

Rapid strides have of late years been made in the various details of itation, which have required great and wholesale improvement; and there is ample room for further advancement in all its branches.

Many defects have been got rid of by sure and proved remedies, there remain many more, which have not been dealt with in such anner that the world can say we have reached a point of success re or less short of perfection; and it is on these varied and contra- ory theories that there is this great amount of disagreement among horities on sanitation; for the patents and so-called remedies put h are too numerous to mention. Therefore it is only the wish of writer to put before the students those things which, we all know, uire alteration for the better, so that any suggested methods herein- r given must not be taken "as recommended"; they are only anced to give the student an idea how such results might be attained.

The various circumstances, and his own well-considered practical ion, ought to decide him as to whose patent and what remedy are be used for particular difficulties. It would be invidious of the or to advertise any one or another person's special patented ideas.

The Model Dwelling.—A "model dwelling," to be up to the uirements of the age and of a healthy life, should be one containing icient cubic contents, area, and light for the purposes required; h a plentiful supply and constant circulation of pure air, cooled in mmer and warmed in winter, without any approach to draughts of any kind, which would affect prejudicially the health and comfort of the inmates.

It should also be provided with a plentiful supply of good pure water; and the sanitary conveniences, of whatever kind, should be so arranged that no bad smells or offensive odours can possibly be emitted, except, as it were, out of the reach of humanity. All drains should be air-tight and water-tight, well and securely trapped, laid with proper gradients, and provided with adequate ventilation, so that a body of pure air, figuratively speaking, may prevail within the appliances, and so that all foul air may be driven out, from point to point, at such places that it is harmless to life.

It must be understood that foul air is lighter than pure air, and for that reason invariably floats, as it were, on the top of the pure air, so that we know where it collects, and therefore have to remove it from the upper part of any apartment, where it accumulates. Pure air is *fouled* or polluted by carbonic acid, which either comes, by the breath, from the lungs, or is emitted from the skin of human beings or animals.

Pure air is also vitiated by sewer gas and bad smells, and by combustion, whether caused by fires, gas, or other means of lighting and warming.

On the other hand, leaves of trees and other forms of vegetation absorb the carbonic acid out of the foul air, and generally act as a sort of purifier and filter to the atmosphere.

For the sake of convenience it will be as well to subdivide the subject of sanitation under two heads, as follows:—

1. Air and Ventilation.
2. Drainage and its Connections.

Air and Ventilation.—Human beings, on an average, require, per head, 300 cubic feet of fresh air per hour to keep them in a healthy state; and for this purpose they must be supplied with that amount of cubic space of pure fresh air, refilled and circulated by the natural pressure of the ingress of the wind, or artificially by fans, from behind, as it were, to drive out the foul air, and replace it by pure air; or that object is attained by extracting the foul air from the top and drawing in the pure air from below.

Assuming that each person requires 300 cubic feet of air per hour, the air in a room 10 feet × 10 feet and 10 feet high, would require to be changed three times in ten hours for one person; so that rooms of various cubic contents require the air they contain to be changed according to the amount of air available for each occupant.

There is no law laying down the superficial area or cubic contents which each private dwelling should have per inhabitant; as such restriction or regulation would be unreasonable and impracticable, though it is generally laid down by local authorities that rooms of less area than 100 feet superficial, by 9 feet high, should have special ventilation beyond that which an unused fireplace with window and door would give. Nevertheless the Local Government Board require that, though 300 cubic feet may suffice for each individual in public dormitories, yet in practice such cubic space should never be less than 850 for sick persons; and, indeed, some hospitals have as much as from 1,000 to 1,200 cubic feet, and more, per patient. The Educational Department require 130 cubic feet per scholar, while lodging-houses should have 30 feet uperficial, or (assuming 8 feet high) about 240 feet cube per person. These figures will give the student an idea of what is required, and also how him how much really depends on the circulation of fresh air.

Draughts.—The various methods for promoting circulation hereinbefore mentioned, having their inlets and outlets by means of flues or ventilators, are apt to cause draughts of various kinds, which it is necessary should be obviated as much as possible; and, with that object in view, a separate supply of air should be provided to feed he fires, which require, under ordinary circumstances, 150 feet cube of air per minute. Unless that supply is made from a special source, it will be drawn to the fire from the door or window, causing a draught between the inlet and outlet; and, consequently, a fire should have an nlet of air contiguous to it, either at the back or sides of the fireplace opening, having an area nearly equal to the outlet, flue, or opening at he chimney-pot.

Down draughts are equally as troublesome, though not so regular, as the fire causes an up draught. Moreover they are not perceptible, unless we have artificial means of ventilation, such as flues and ventilators, which at times are converted, by circumstances, temporarily into sources of this defect; and this all good patents and remedies should render mpossible.

Draughts sometimes are driven down outlet flues; and this can be remedied, or reduced to a minimum, by the use of flap ventilators made of mica or other light material, which can be moved or opened by an up or outlet draught, and closed by a down draught. At other times they are caused by the air rushing through the inlet, which strikes against anything such as a ceiling, and comes down on people's heads; or the stagnation of the foul air at the top will press it down.

The heat of a fire or hot-water pipes will draw from windows and skylights in very cold weather, and create serious draughts; hence in the best hot-water work provision is made for running the pipes around the skylights or intermediately, so that the cold air has to pass the heated pipes.

Common sense gives us the remedies for these: either by increasing the outlet for foul air, or by regulating the supply; though this latter is not to be recommended.

It should be understood that a larger inlet than outlet increases the velocity with which the air circulates, and drives out the foul air all the sooner.

Ingress of pure air can be, or rather should be, of two kinds—warm for winter, and cold for summer. It can be brought in by the following methods, among others:—

External Ventilators as Inlets.—External ventilators, connected by flues to the inside, where valves, flaps, and shutters should be utilised to shut off and regulate the supply at pleasure. A common place to fix these is a little above skirting level, especially in window backs and recesses; and they should be supplied with sliding shutters, of hit-and-miss form, so that, by a slight movement of the shutter, the ingress of cold air may be regulated, or shut off when not wanted. This position for ventilators may be said to obviate the evils at its origin, inasmuch as it clears the air from the bottom of the room upwards; though it is apt to cause undercurrents and unpleasant draughts, to remedy which ventilators are used of the Tobin class, which are fixed generally half or part of the way up the external walls. They consist of external open gratings, connected by flues either to wooden shafts—such as pilasters, etc., more or less ornamentally treated, which are often placed within the rooms—or at other times, where the shafts would be inconvenient and out of place, the inlet is made by an ornamental bracket, projecting into the room, and this is connected by a shaft or flue, within the walls, to the external air grating. The fresh air enters the room at the top of the bracket (fitted with a valve to open and shut), and the force of the air is expended upwards, so that no draught is caused.

Ventilators are also fixed at or a little below ceiling level, and they are constructed of an external open-air grating, connected by a short flue to the inside ventilator, which is constructed on the hopper principle, with closed sides, so that the current of air has a tendency to go upwards. These precautions, however, do not successfully combat down draught, inasmuch as, while they remedy one defect, they cause the air to come in with considerable velocity on to the heads of persons below, which is a great defect. Hence, of the three places in which air can be brought into a room, the best place is midway, as the above will explain.

Fresh air can also be supplied to a room by means of the window, and this, too, without causing draught. The stop-bead on the sill is made 2 or 3 inches deeper, so that, by raising the bottom sash, the air is admitted through the space made at the meeting rails of the sashes thus opened.

Ventilating Fans.—Another means of ventilating apartments, and promoting a circulation of air, is by the use of fans propelled by mechanical means, which drive the collected fresh air through flues into the rooms, the inlets to the rooms, of course, being fixed at such a distance above the floor that all feeling of draught is obviated. The cold air is taken or drawn down a shaft into the basement, and passes through a fan, which is connected to a series of large flues, and these, in their turn, are extended into various independent smaller flues, which run up the chimney-stacks or upcast shafts, and have inlets opening into the numerous rooms on the different floors above.

At other times the foul air is drawn out by mechanical means, at about the skirting level, into flues connected to shafts, having exits in roofs, towers, etc.; and this egress creates such a vacuum that fresh air is drawn in through other flues, having inlets into the rooms, 7 or 8 feet above the floor, connected to air inlet shafts collecting the fresh air from the open.

The supply of fresh air to rooms is a small matter in comparison with the warming and cooling of it in summer and winter, and this is a matter which is only in its infancy as yet; the only method in vogue at the present time consists purely of passing the air over or through coils of pipes, etc., containing hot or cold air, or over boxes of ice and steam-heated pipes; and this means is only applicable (1) to the "fan" process, which explains itself, and (2) in cases where coils can be fixed between the inlet ventilators and the space to be ventilated, so that all fresh air must pass over or be acted upon in a more or less degree by the hot or cold appliances. Where fans are used, the fresh air can also be washed on a screen—which is very desirable.

In arranging systems of ventilation great care should be taken that the water closet and sanitary apartments are ventilated independently of kitchens, dwelling-rooms, etc.

The egress of foul air can also be provided for by the fresh air driving in through top ventilators, or by extraction. The former method allows of various forms, including:—

1. Independent ventilating flues, constructed in the chimney-stacks, and carried up to the top and out into the open. These are the most commonly used remedies, and their only disadvantage is their liability to down draught; but this can be obviated by the use of the mica *flap* ventilators previously mentioned, which will only act one way as extractors, a contrary action closing them, as in the case of a down draught.

2. Outlet ventilators may also be constructed in ceilings, a flue of zinc connecting the outlet to a flue into the stack or outlet vent in the roof, as just mentioned; and these have the advantage that they can be ornamentally treated, in that we can use perforated centre flowers and cornices as outlets—the former being very efficacious, when the

warmth of the gas will help to draw the foul air to the outlet and drive it away.

Warmth in outlet flues will always increase the velocity of the outcast, whether burning jets be inserted at the bottom of the flues or the flues themselves be warmed or surrounded by warm smoke flues, care being taken that smoke flues are not utilised as ventilators, unless great care can be exercised and very superior and tight flaps be used.

The extraction of foul air is usually attained by means of patent appliances, called *air pumps*, which are generally self-acting. These patents mostly take the form of cowls, which are fixed on the top of the special shafts or on roofs, the various small pipes being brought together in a main shaft, at the top of which the extractor is fixed, and this draws out all foul air, or rather it increases the velocity, and causes an "upcast"; but the efficacy depends on the movement of the external air very much.

It should be noted that the various small flues must not be *let loose* into the main stack, inasmuch as the different currents would clash, and form an injurious whirl, as it were, which would cause an obstruction. They must be kept independent of each other, or be gathered together one by one as they get near the extractor.

Drainage.—Coming to drainage, we will start from the outfall into the main or public sewer, and deal with the drains, water closets, baths, lavatories, sinks, and other apparatus in connection therewith, calling attention to those points requiring special study, whether the system be in connection with a *common sewer*, cesspool, or scheme of irrigation.

It may be stated at the outset that, wherever practicable, it is always advisable to intercept, or disconnect, that portion of a dwelling in which the sanitary conveniences are placed, from the main block of the house, by a lobby having a cross current of air constantly circulating through it.

It is generally acknowledged by most sanitarians that the house sewer should be disconnected from the public sewer or cesspool by some properly devised trap placed as near the end of the house system as possible, as house sewers not so disconnected allow the free admission of any fever germs which may have found their way into the public sewer from some contaminated source. Otherwise householders would have to rely entirely upon the internal fittings of the house for their protection; and in such cases as (1) the temporary removal of a water closet for repairs, without sealing the pipe end; (2) an accident to a trap, causing the water to run out; or (3) the unsealing of a gully during cleaning operations or the evaporation of water during a dry season (all of which may occur in the average dwelling), the inmates would be exposed to the risk of these germs gaining admission to the house—a risk too serious to be contemplated or permitted.

Traps.—The various kinds of traps (a trap being an appliance devised to prevent the rising and entrance into the house of sewer gases by the water which it contains) in use for this purpose of disconnection are too numerous to mention, the main point being that they should be constructed so as to have a dip at the outlet, shown at A, fig. 991, to allow the standing water in the trap to be more forcibly acted upon by the discharges down the house sewer, so that the water may be properly changed. The body of the trap B should also be reduced to allow of a better seal being obtained (of, say, 2 or 3 inches), without having too large a body of water to resist the flush through it, and of course such reduction must be kept within reasonable limits, or the trap would be liable to choke by solid matter passing down the sewers; and it is very desirable that there should be an inspection arm on the trap, as fig. 992, to allow of any obstruction in the drain below being removed.

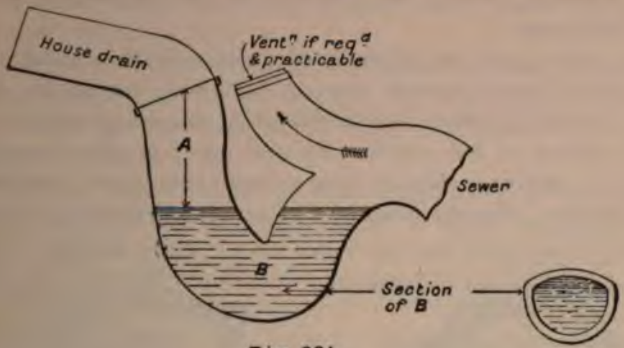


Fig 991

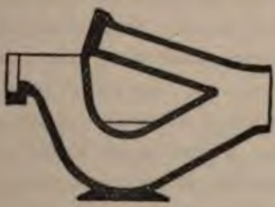


Fig 992

These traps should be placed below a brick-built chamber, as fig. 999, so that the trap itself can be easily and conveniently cleansed, when required; while the open cover can be utilised as an inlet to ventilate the house drain above, as shown, all possibility of sewer gas arising being obviated by the trap; and when there is an inspection arm, it should be securely fixed, that the joint may be absolutely air-tight.

Drain Pipes and Testing.—The next point for consideration is the house sewer and its branch pipes from this disconnecting trap to the various positions required to receive the solid and liquid matter from the house appliances; and it may be mentioned at once that too much care cannot be bestowed upon the laying of these conduits, as leakages from faulty joints or imperfect pipes will percolate through the soil to a great distance, and may eventually locate themselves, and the evils arising therefrom, beneath the dwelling, to the detriment of the health of the inhabitants.

These drain pipes are generally of glazed stoneware, about 2 feet in length; but of late years many schemes have been carried out in strong cast iron, having its surface coated with glass enamel, or with Dr. Angus Smith's solution of hot coal tar, oil and resin, or other non-corrosive material, the advantage claimed being a better connection, that will stand a high pressure, powerful flushing, and a reduced number of joints, on account of the iron pipes being in 9-feet lengths, as compared with 2-feet lengths in stoneware pipes. Stoneware pipes, however, have this strong point in their favour—that they are made of an imperishable substance, which iron is not; and, moreover, iron pipes, properly treated, cost nearly double the price of stoneware pipes, bedded in concrete as an additional precaution. These pipes should be egg-shaped, so that a greater hydraulic depth can be obtained for small flushes, to enable them the better to allow the water to carry any solid matter with them, scouring out the drain completely, and also to increase the velocity of the flow.

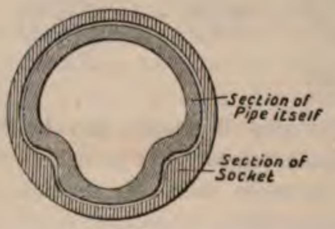


Fig 993.

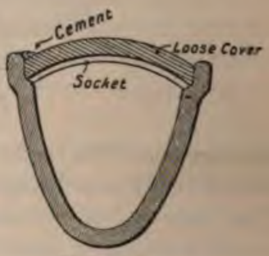


Fig. 994.

This reduction of the width of the channel, with its corresponding increase of depth, is attained by the use of pipes similar to figs. 993 and 994, the latter of which—on account of its loose lapped cover—reduces to a minimum the risk of obstruction formed by the squeezing up of the cement used in bedding the bottom joint. Both these pipes have another advantage, in that they do not require so much water to flush them.

They should be laid perfectly straight, on a solid foundation of concrete, and to a gradual fall from point to point (of, say, 2 inches in 10 feet), according to the size of the pipe—a simple method for calculating the fall of drains and sewers being to multiply the diameter by 10 and call it feet, the result being the length of pipe that should have 1-foot fall—*e.g.*, 4 inches × 10 = 40 feet, or 1 foot in 40, the required fall for 4-inch pipes.

It should be borne in mind that this is the minimum rate of fall that is advisable and likely to answer its purpose, and a greater fall should be the aim of the sanitarian.

If the fall is not sufficient, the contents are likely to silt up and choke the drain; while if too much fall is given, the liquid matter will run too quickly away from the solid, which would thus accumulate, and also choke up the pipes.

The inside circumference of the pipes should be in perfect alignment when fixed together, and all joints should be made thoroughly sound; those in stoneware where patent joints are not employed being made of tarred spun yarn and cement, the cement being mixed with clean sand, in the proportion of about 1 and 1 (otherwise the expansion in setting is liable to crack the sockets), and care should be taken that no cement or projection is left on the joint in the inside of the pipe; while in the case of cast-iron pipes the joints are made by lead being well caulked into the sockets, so that the pipe joints are strong enough to stand the smoke, peppermint, or water-pressure tests, the latter being the best, consisting of blocking up the drain at the outfall and filling with water, which will be retained at a regular level if all is secure. All drains in close proximity to dwelling-houses should stand the water test, otherwise a stoppage in the pipes, causing them to fill up at any time, would force the joints, and cause leakages that may never be discovered.

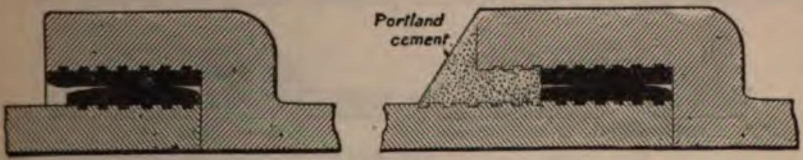


Fig. 995.

The other tests are applied by forcing fumes of smoke or peppermint into the pipes; and these fumes, if the system is secure and a good job, should not escape at any place (so that the odour should be perceptible) except at the top of the soil or vent pipes.

Of the patent systems of jointing stoneware socketed pipes one of the most important is Doulton's self-adjusting joint, fig. 995, which consists of concave and convex rims made of hard, imperishable material, and which are attached to and incorporated with the material of the spigot and faucet ends of the pipes, the spigot end fitting into the socket or faucet, both having previously been smeared over with an oily mixture, so that a turn of the pipe will cause a close-fitting joint to be made

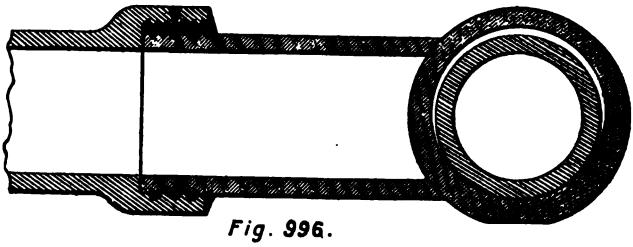
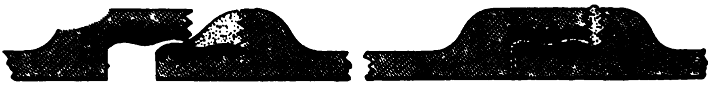


Fig. 996.

between the hard, true surfaces of the rims. Another form of oint is the Albion "Paragon," similar to fig. 996, which explains itself, the clay or cement being forced by the insertion of the spigot to make a water-tight joint. A still later and more improved kind is known as "Sykes" patent joint, as fig. 997, from which it will be gathered that, being a screwed thread,



Joint ready for screwing home

Joint as made

Fig. 997.

so to speak, to be twisted into position, it can be made by the ordinary workman, the jointing material being said to be water-tight and imperishable, and yet flexible—the quality which has been a long while sought, as it is impracticable to make a perfectly rigid joint water-tight, owing to settlements in the ground.

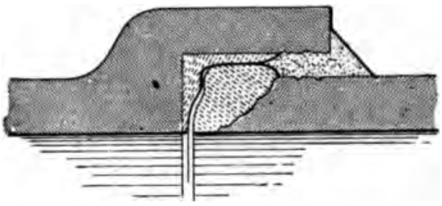


Fig. 998.

Another similar joint is illustrated by fig. 998, which also allows of flexibility in the connection—a point which, together with the fact that perfect alignment is rendered the more certain, gives a great deal of preference to patent-jointed pipes over the ordinary rigid cement and yarn; this latter being most uncertain, owing to unequal settlements of the ground.

Further, the mere filling-in of the soil in deep drains often breaks the joint, no matter how carefully the ramming is done, and moreover, it requires most close supervision and inspection to be sure that no cement has been squeezed up at the bottom of the joints to cause obstructions in the channel.

Inspection Openings and Ventilating Inlets.—Where these pipes take a different angle (forming an elbow), or have a junction one with the other, inspection chambers should be provided, having air-tight covers if in a situation where open grates would be objectionable; though these manhole or inspection chambers, where required and practicable, should be utilised to get the necessary passage of pure air through the pipes, as fig. 999, the lower part of course being properly trapped and securely ventilated from above, as shown; for the mere fact of carrying a soil pipe up full bore above the eaves of the roof will not cause circulation, unless an air inlet is also provided at a lower level.

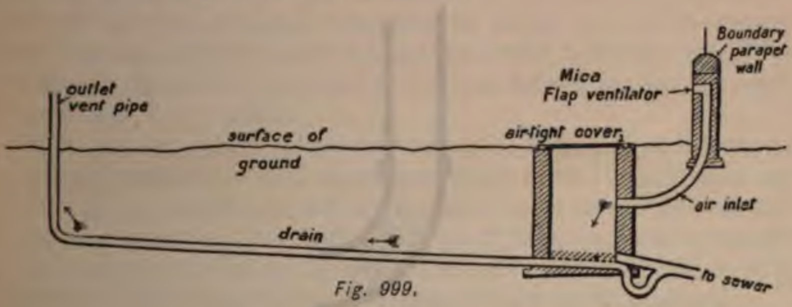


Fig. 999.

Great care should be taken to provide the fresh-air inlet of an area equal to or slightly larger than that of the outlets, which is an important item, very frequently neglected; and it is best, where practicable, to admit fresh air separately to each branch at that point where it joins the main house sewer; and, if this is not practicable, the main inlet at the chamber next the sewer should be large enough to supply the various branches which it has to receive; and where fresh air cannot be supplied by these chambers, it should be let in by means of shafts (sometimes in a wall) provided with mica flap ventilators, to prevent the back pressure of foul air.

Ventilating Outlets.—Cowls are sometimes fixed at the top of the outlet of the ventilating pipes, with the object of increasing the up current; but this is attended with such variable results that an open pipe end, protected from birds'-nests, etc., by a copper wire cage, is preferred by most sanitarians; and if in a position where snow is likely to block up the top in winter, slits should be cut longitudinally in the top of the pipe to give the necessary outlet.

In cases where these ventilating pipes are fixed to trees, they should be constantly examined, or provided with expansion joints, as the growth or movement of the tree might disturb the jointing.

All ventilation pipes should be coated with non-corrosive substance and with molten lead joints. It has been discovered that uncoated pipes very soon rust and crumble, the scales of rust falling to the bottom of the pipe, where it is connected to the drain, and here it accumulates, until a heap is formed which entirely blocks the egress of foul air (see fig. 1000).

Flushing.—To ensure thorough cleanliness in sewers, it is necessary that a means of regular flushing should be adopted; and this can be done in several ways,—either by collecting the rain water in an automatic flushing tank connected to the sewer (in such a manner that foul gas cannot get out) at the head of the system, or by providing a constant supply of water to a flushing tank that can be regulated at will to discharge a certain quantity of water, automatically, as circumstances require—more frequent in warm weather than in cold—though it is not advisable to have too large a discharge, as it is apt to disturb the seals of the various traps on the branch sections, from 20 to 30 gallons being a sufficient quantity for flushing an average house sewer system.

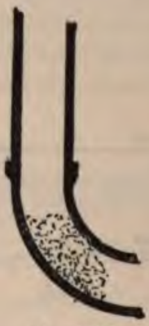


Fig. 1000.

Oftentimes drainage systems can be properly flushed by the frequent use of the bath when placed at the head of the system, and the smaller the drain pipe the greater the chance of sending down a volume of water the full bore of the pipe, which is absolutely necessary to give confidence and security.

Where there is no public sewer for the proper disposal of sewage, as in the case of isolated mansions and country houses, the sewage has to be dealt with by cesspools, or by surface or sub-irrigation, the latter method being the most preferable.

Cesspools.—When cesspools are used, they should be situated as far as possible from the building and clear of any storage tanks or source of domestic water supply, their walls and bottoms being perfectly water-tight, and the tank large enough to obviate frequent clearing out; though the other extreme is just as bad. They should be well ventilated by pipes terminating at the most favourable position that the surrounding circumstances will allow; and the overflow should be so constructed that as little harm as possible is likely to occur from it, though cesspools are bad and injurious, even when necessary, constructions; and in all cases the house sewer should be disconnected from them, as hereinbefore referred to.

Sewage Irrigation.—There are two methods of disposal by irrigation —namely,

1. *Surface* irrigation, which consists in distributing the sewage matter over the surface of properly prepared land, the liquid being drained off at a depth which will ensure its being deodorised before being allowed to flow into a stream or river; and,

2. *Sub-irrigation*, by which solid matter is collected in tanks, constructed and subdivided, so that the liquid part is forced through beds of sand and charcoal into other compartments (as fig. 1001), from which it should be automatically flushed out and distributed below the ground, at a depth of, say, 2 feet, by means of ordinary field drains laid a certain distance apart in dry rubble.

It is necessary that the distribution should be large and intermittent to prevent the trickling of small discharges, which make the soil round the tanks boggy and unpleasant, because the liquid never gets beyond the first two or three pipes; and it is desirable to have all irrigation tanks constructed in duplicate, to allow of one set being cleaned out while the other is in operation, without interfering with the regular working of the scheme.

It is needless to add that sewage irrigation depends very much on the nature of the ground through which the pipes are run—a gravelly soil, or any other through which the liquid will percolate quickly, being the desideratum of a sanitary engineer.

Before leaving house sewers, and passing on to the consideration of soil pipes and water closets in connection therewith, the writer would impress upon the student the necessity of careful thought in dealing with drainage schemes, as errors have, frequently, most serious results.

Water Closets and Soil Pipes.—Every water-closet apparatus, on whatever principle, whether *valve*, *wash-down*, or *wash-out*, should have the following properties, to secure safety:—

1. Simplicity in its working parts.

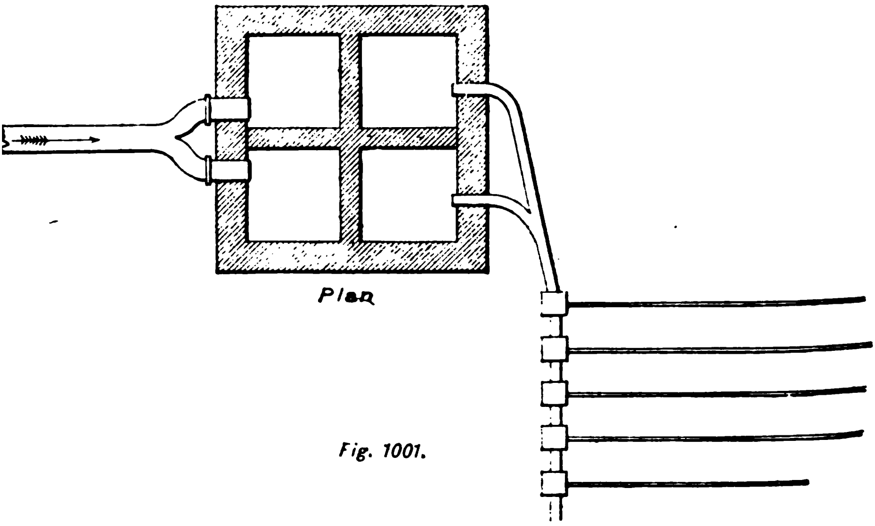
2. A proper trap in connection with it; having a seal of not less than 1¾ inches (many have but half this).

3. A sufficient depth of water in the basin to cover the excreta, and so suppress bad smells.

4. Such means of connection to a soil pipe as will ensure a perfect,

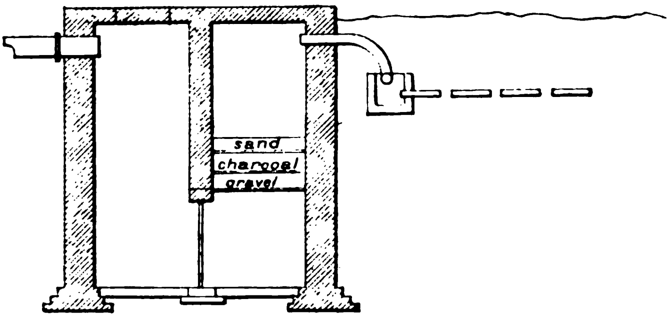
permanent, and secure joint—a point which also applies to the ventilation horn of the trap.

5. A flushing arrangement that will allow of a flush of from 2½ to 3 gallons of water, to completely change the body of water contained in the basin and trap, and carry the excreta and paper to the farthest possible distance.



Plan

Fig. 1001.



Section

6. It should have no dry surface exposed to contamination.

All closets having these qualities may be considered to be appliances that will meet all usual requirements, and they are connected to the drain below by a soil pipe of glass-enamelled or coated cast iron, or lead (the latter being the most lasting substance when properly fixed); and such pipes should, in all cases, be always fixed outside, and carried up full bore to the ridge of the roof, terminating at a position remote from all windows or openings into the house, and away from any projection likely to cause a back draught in the pipe.

There is a diversity of opinion as to the size of these soil pipes, some sanitarians requiring 4 inches diameter for each closet, while others are satisfied with a 2½-inch pipe for a stack of three closets; the writer's opinion being that if the pipe be large enough to carry away the solid matter deposited in the basin, the smaller size undoubtedly offers the greater certainty of being kept clean.

Where the branch piece between the outlet of the apparatus and the stack outside is of any considerable length, the trap should be ventilated separately, as also in cases where more closets are fixed on one stack, when each trap should be separately ventilated by a pipe carried up to a position higher than the upper apparatus, and then branched into the main vent pipe—precautions which are absolutely necessary to prevent syphonic action unsealing the traps by removing the pressure at one side of the water seal; and many cases have occurred in which ignorance of this important matter has been the cause of an escape of sewer gas into a dwelling.

Where lead soil pipes are connected to iron or stoneware, a brass ferrule should be wiped on to the end, to allow of a properly caulked joint being made; and all soil pipe joints should be made perfectly air- and water-tight, besides which it is sometimes advisable to treat soil pipes locally, and disconnect them from the house drain or sewer by a trap at the foot, ventilated separately, as fig. 1002, which reduces the risk of sewer gas, in case of any defects to internal fittings; and where this is done, of course a separate ventilating pipe is required for the drains, irrespective of the soil pipes.

Baths, etc.—The next question is that of the baths, lavatories, and sinks, which it is necessary should be constructed in such a manner as will allow of themselves and their surroundings being kept thoroughly clean and wholesome, provision being made to allow of regular inspection for cleansing purposes, when these fittings are enclosed in woodwork; though it is much to be preferred, from a sanitary point of view, that they should be fixed without enclosures, especially sinks, and they should also be clear of all angles and ledges where filth is likely to accumulate.

The outlet fittings to these appliances should be of the description known as full-way fittings, having an area of space through the holes of their grates equal to or slightly larger than the bore of the waste pipes fixed to them, so as to ensure such waste pipes being thoroughly flushed and scoured by each flush sent down them, bath and sink waste pipes being not less than 2 inches in diameter, and those of lavatories 1¼ inch, with traps fixed immediately underneath the appliances, and properly ventilated to prevent syphonage.

Although the legitimate use of a bath is to cleanse the human body, its discharge of from 30 to 50 gallons of water can be utilised with great advantage as a flushing force for cleansing the drains, as hereinbefore explained, and for this reason the bathroom should be situated as near as possible to the point where the discharges therefrom will act on the whole drainage system, the benefit of which is obvious to all; and to utilise this force properly, it is absolutely necessary that full-way fittings and pipes be used, and the waste made to deliver in the open air on to a proper disconnecting trap similar to fig. 1002, but with no inlet—the waste water discharging on to the grating; and this same form of gully should be used to secure lavatory or sink discharges, excepting the case of the latter having large discharges of grease likely to choke the drains, when a proper grease trap should be fixed in a position far enough away, or sealed in such a manner as not to be offensive; but, where there is not sediment enough to require such an appliance, it should be flushed clean through the above trap and into the sewer.

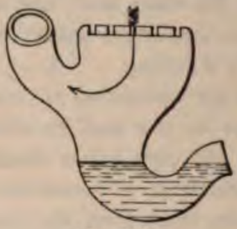


Fig. 1002.

The ordinary yard gully is an appliance totally unfitted for the purpose of receiving discharges from baths, lavatories, and sinks, as it is more of a filth-collecting and retaining appliance, which throws off injurious emanations from the decomposed matter which it contains; and, moreover, when fixed outside, they are usually in such close proximity to the house as to allow these noxious gases gaining admission thereto, and then they become, practically speaking, small cesspools about a house. *Anti-bell* or *adjustable traps* (as figs. 1003 and 1004) should always be used, the latter, as the name implies, being capable of regulation according to circumstances of fall, etc.

In dry seasons and hot weather it is essential that the gullies, whether from waste or rain pipes, should be frequently supplied with water to maintain the proper seal, which is easily dried up, and becomes a great source of danger. A sanitarian's aim in arranging sewerage work should be to avoid stagnation and the consequent accumulation of foul gases by so ıg the pipes that a constant current of fresh air can be maintained r pipe and drain, including wastes, overflows, soil pipes, etc., giving ıciple of diffusion its fullest extension, and at the same time taking at in no case shall any waste or other such pipe act as an inlet or to the building.

ter Supply.—Good pure water is naturally most essential for the of human beings; and, as a rule, it is supplied by private or public so that it is only necessary here to deal with its storage and tion. Sometimes, though very seldom, the water is on constant which obviously does not necessitate any storage capacity to ;gainst a dearth when the water is turned off.

ks are used for this purpose, and made of wood lined with lead, ;alvanised iron, if the water is hard and heavy; but where the soft, either vitrified stoneware or slate is preferable, as the soft cts upon the lead, rendering it injurious and unfit for drinking :s.

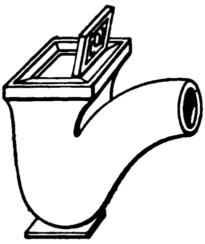


Fig. 1003.

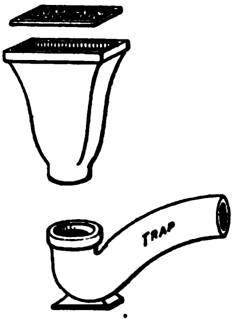


Fig. 1004.

ɜ should be taken to place these cisterns in a position clear of all of contamination from sleeping chambers, dust, or foul air, and ɔuld be covered with a dust-tight lid, easily removable for cleaning.

: overflow pipes from cisterns should terminate in a position quite any waste pipes or other fittings, and be in diameter twice the the inlet or feed pipe; while stop taps should be placed in a ent position to control the supply both to and from the cistern, ıly pipes being properly fixed to wood grounds, kept away from l places, where they would be liable to be affected by frost.

is also an important matter, and one which oftentimes saves rable anxiety and not a little inconvenience and expense, to so the water supply that the risk of freezing is reduced to a m, and this may be effected by care and a little attention when ıg the supplies. First of all, external pipes should be not less than 30 inches below the surface of the ground; and where they are not in the ground, they should be wrapped in thick hair felt enclosed in wood pipe casings. On entering the house a stop tap should be placed below a bib tap, so that all the water in the house can be drawn off after the stop tap is closed; and from thence the pipe should be run on internal walls within wooden pipe casings to the cistern, the supply to boiler from thence being fixed in casings grooved to allow of the hot pipes going in the same casing, and yet not contagious to the cold supply, as fig. 1005; a more or less ornamental cover being screwed on to hide the pipes.

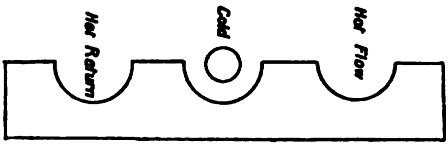


Fig. 1005.

APPENDIX.

.LABUS OF THE SUBJECTS IN WHICH EXAMINATIONS IN BUILDING CONSTRUCTION ARE HELD BY THE DEPARTMENT OF SCIENCE AND ART.

TE.—*The Department announce that a larger number of questions will be set in the Examination Papers for the Elementary and Advanced Stages than the candidate will be allowed to attempt, so that he will, to a certain extent, be able to show his knowledge in such branches as he may, from circumstances, have paid special attention to.*]

First Stage, or Elementary Course.

s assumed that the student has already mastered the use of the follow- drawing instruments: rulers, ordinary and parallel; ruling pen; passes, with pen and pencil bow-sweeps, as well as the construction use of simple scales, such as 1, 2, 3, or more feet to the inch, showing ies; or such as $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{2}{3}$, $\frac{3}{8}$, $\frac{5}{8}$, or other fraction of full size, or of any n scale or drawing; also the meaning of such terms as Plan, Elevation nt, back, or side), Section, Sectional Elevation.

He should understand the object of bond in brickwork—*i.e.*, English d, Flemish bond, or English bond with Flemish facing, and how it tained in walls up to three bricks thick in the following instances—viz., ings with offsets, angles of buildings, connection of external and internal s, window and door openings with reveals and square jambs, external ged arches (camber, segmental, and semi-circular), internal discharging ies over lintels, and inverted arches.

He should know where to put wood bricks, or plugging, and their use; construction and uses of brick corbelling, and the construction of mer arches in fireplaces.

He should be able to give sections and elevations to scale of the follow- kinds of mason's work—viz., uncoursed and coursed rubble, block in rse, and ashlar, with their bond, and the proper dimensions of the stones, as to height, width of bed, and length; and of the following dressings—viz., window sills, window and door jambs, plain window and door heads, door steps, string courses, quoins, copings, common cornices, blocking courses; and of the following methods of connecting stones—viz., by cramps, dowels, joggles, and lead plugs.

He should be able to show how to join timbers by halving, lapping, notching, cogging, scarfing, fishing, and mortise and tenon; as applied to wall plates, roof timbers, floors, ceilings, and partitions.

He should be able to draw, from given dimensions, couple, collar, and king-post roofs, showing the details of the framing and of the ironwork.

He should be able to draw, from given dimensions, single, double, and framed floors, with or without ceilings beneath them; showing modes of supporting, stiffening, and framing the timbers, trimming round hearths and wells of stairs; also floor coverings of boards or battens, rebated and filleted, ploughed and tongued, and laid folding, with straight or broken joints, bevelled or square heading joints.

He should be able to draw in elevation, from given dimensions, a framed partition with door openings.

He should be able to draw in elevation, and give vertical and horizontal sections of solid door frames and window frames.

He should be able to describe, by drawings, beadings of different kinds, dovetailing, cross-grooving, rebating, plough-grooving, chamfering, rounded nosing, and housing.

He should be able to draw in elevation, and give vertical and horizontal sections of, the following doors,—viz., ledged, ledged and braced, framed and braced, panelled, and the mode of putting them together, position of hinges and furniture; as well as to describe, by drawing, the following terms as applied to panelled door—viz., square and flat, bead butt, bead flush, moulded, all on one or both sides.

He should be able to draw in elevation, and to give vertical and horizontal sections of the following window sashes and frames—viz., single or double-hung sashes with square bevelled, or moulded bars, and cased frames; casement sashes hung to solid frames, with method of hanging and securing in each case.

He should be able to show, in elevation and section, the lead-work connected with chimneys, ridges, hips, valleys, gutters, and lead-flats.

He should be able to give an elevation and section of the slating of a roof laid with duchess or countess slates on boards or battens.

He should be acquainted with the proper cross-section for cast iron beams for use in floor girders or bresummers, or as cantilevers; and be able to draw such a section in its right proportions from given dimensions of flanges.

He should be able to draw in elevation, from given dimensions and eton diagrams, ordinary iron roofs up to 40-feet span, showing the ions of different parts, and methods of connecting them.

Second Stage, or Advanced Course.

In addition to the subjects enumerated for the Elementary Course—in of which questions of a more complicated nature may be set, combining k done by the different trades—the knowledge of the students will be ed under the following heads, viz.:—

1st. Freehand sketches explanatory of any details of construction, such the joints of iron and wooden structures, and other parts requiring stration on an enlarged scale. These sketches may be roughly drawn, vided they are clear and capable of being readily understood.

2nd. The nature of the stresses to which the different parts of simple ctures are subjected, as follows:—

In the case of beams either fixed at one or both ends, or supported or tinuous, the student should know which parts of the beam are in npression, and which in tension.

He should be acquainted with the best forms for struts, ties, and beams, h as floor joists, exposed to transverse stress.

He should know the difference in the strength of a girder carrying a en load at its centre, or uniformly distributed.

In the ordinary kinds of wooden or iron roof trusses, and framed ictures of a similar description, he should be able to distinguish members compression from those in tension.

He should be able, in the case of a concentrated or uniform load or a t of a beam supported at both ends, to ascertain the proportion of the d transmitted to each point of support.

3rd. The nature, application, and characteristic peculiarities of the lowing materials in ordinary use for building purposes, viz.:—

Bricks of different kinds in common use, York, Portland, Caen, and h stones (or stones of a similar description), granite, pure lime, lraulic lime, Portland and Roman cement, mortars, concretes, grout, halte, timber of different kinds in common use, cast and wrought iron, l.

4th. Constructive details, as follows:—

The ordinary methods of timbering excavations, such as for foundations walls, or for laying down sewers; the erection of bricklayer's and son's scaffolding; the construction of travellers; the use of piles in ndations, hoop-iron bond in brickwork, diagonal and herring-bone irses in ditto, damp-proof courses, bond timber in walls, and the ections to it.

He should know how bricks are laid in hollow walls, window or door openings with splayed jambs, flues, chimneys, fireplaces, and arches up to about 20-feet span; how mortar joints are finished off, and the thickness usually allowed to them; why bricks and stones ought to be wetted before being laid.

He should be acquainted with the construction of brick ashlar walls, rubber ashlar walls, stone stairs, wooden stairs (both dog-legged and open newel), skylights, fire-proof floors (such as brick arches supported on rolled or cast-iron girders, Fox and Barrett's, and Dennett's patent concrete floors), circular and egg-shaped drains, roofs of iron or wood, for spans up to 60 feet; the fixing of architraves, linings, and skirtings to walls, shutters to windows, lath, plaster, and battening to walls, roof coverings of tiles and zinc, slate ridges and hips.

Examination for Honours.

Written answers will be required to some of the questions.

The candidate will have to furnish a design for a building, or part of a building, in accordance with given conditions, which design he will be allowed to draw out at his own home.

He will be called upon to answer in writing—illustrated by sketches either freehand or to scale, as directed—questions on all the subjects previously enumerated for the elementary and advanced Courses.

He must possess a more complete knowledge of building materials, their application, strength, and how to judge of their quality; and in the case of iron, of the processes of manufacture, and the points to be attended to in order to insure sound castings, and good riveting.

He must be able to solve simple problems in the theory of construction, and to determine the safe dimensions of iron or wooden beams subjected to dead loads.

In ordinary roof trusses and framed structures of a similar description, he must be able to trace the stresses, brought into action by the loads, from the points of application to the points of support, as well as to determine the nature and amount of the stresses on the different members of the truss, and, consequently, the quantity of material required in each part.

In ordinary walls and retaining walls he must be able to ascertain the conditions necessary to stability, neglecting the strength of the mortar.

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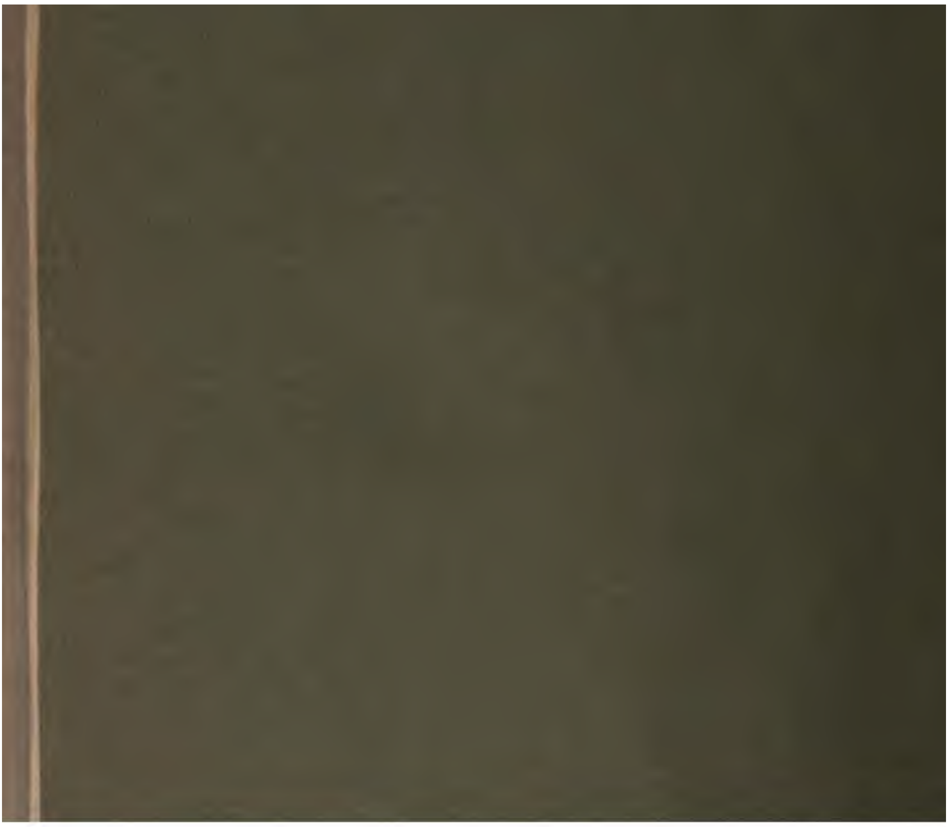

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